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The effects of technological change on the manpower and training needs of New York State industry were studied in a survey of 281 Industrial situations. The study was designed to help answer questions about the effects of factory and related technological change in displacing workers, in creating recruitment and training needs, and in altering the skills required of persons working on or in connection with industrial equipment during the period from 1962 to 1966. Of the situations studied, 15 involved the installation or modification of automatic production lines; 39 the addition of instrumentation to equipment; 105 metalworking and related equipment; 35 mechanical material handling and moving equipment; 20 packaging and related equipment; 29 assembly and related equipment; and 47 other equipment. Some jobs were eliminated in 259 of the 281 cases studied, with 4,542 workers being affected; however, the survey found that while the replacement of one type of machine by another was accompanied by upward skill changes in some cases and by downward changes in others, the number of no-change cases was numerically most important. (CH)

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MANPOWER IMPACTS OF INDUSTRIAL TECHNOLOGY

STATE OF NEW YORK
Nelson A. Rockefeller, *Governor*

DEPARTMENT OF LABOR
M. P. Catherwood, *Industrial Commissioner*

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PREFACE

This report presents the findings of studies, made over the period of several years by the New York State Department of Labor's Division of Research and Statistics, of the impact of technological change on the jobs of workers in the State. These studies were concerned primarily with the displacement of workers from jobs, training and retraining, and changes in the skill required of workers.

The report, which deals primarily with technological change in manufacturing, is a companion volume to a report of the Division on installations of electronic data-processing equipment. 1/

The cases included in the study are illustrative of a wide variety of contemporary technological changes, both automation and other advanced types and more conventional types of mechanization. However, they cannot be said to be representative of such changes, for their selection did not proceed from any defined universe of technological change.

Despite this limitation and other significant limitations arising from incomplete data in a number of cases, the studies should help to identify main trends and contribute to realistic perspectives on manpower impacts of modern industrial technology.

The survey was carried out under the direction of Charles A. Pearce, Director of the Department's Division of Research and Statistics. Staff work was supervised by Harold Loeb, Associate Economist, who also assisted in the preparation of the report. In addition to staff of the Division of Research and Statistics, four consulting engineers -- Lawrence J. Centrello, David A. Gross, Norman L. Naidish, Max Stein -- contributed to the field aspects of the survey during periods in 1965 and 1966.

M. P. Catherwood
Industrial Commissioner

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1. New York State Department of Labor, Division of Research and Statistics, Manpower Impacts of Electronic Data Processing (1969).

HIGHLIGHTS

Although it is quite apparent that automation and other contemporary technology do displace workers from jobs, alter patterns of skill requirements, and create training needs, such effects are not novel nor the sort that suddenly create needs or problems that cannot be met. Typical changes have had minor impact, and there is no reason for supposing that the present trend may be suddenly shifted within the next few years by revolutionary changes that will cause wholesale displacements or create serious skill shortages.

Most of the cases studied here did involve the elimination of one or more jobs. However, only about one-fourth of the workers who held these jobs were separated from employment with the firm, for some were placed in another department and the others -- the bulk of workers affected -- were shifted to jobs on the new equipment. These shifts were accomplished without large movement of workers either up or down the skill ladder and without the need for manning jobs at radically different or substantially higher levels of skill. Training and retraining, for the most part on the job, contributed significantly to preparing workers for their role in the new technology.

These in general are the findings of this survey of 281 industrial situations, which was designed to help answer questions about the effects of factory and related technological change, during the period from 1962 to 1966, in displacing workers, in creating recruitment and training needs, and in altering the skills required of persons working on or in connection with industrial equipment.

The cases surveyed include both conventional and advanced technology and illustrate the kinds of technological change that have been occurring in New York State in recent years, particularly in manufacturing industries. It cannot be said, however, that the sample of cases covered is representative, for their selection did not proceed from any defined universe of technological change.

For the most part the changes studied were small and incremental or evolutionary in nature. Despite a special effort to search out cases of advanced automation involving large numbers of workers, few were encountered during the survey.

Of the situations studied, 15 involve the installation or modification of automatic production lines; 39 the addition of instrumentation to equipment; 105 metalworking and related equipment; 35 mechanical material handling and moving equipment; 20 packaging and related equipment; 29 assembly and related equipment; and 47 other equipment.

Displacement of Workers

Some jobs were eliminated in 259 of the 281 cases studied, 4,542 workers being affected. Most of these workers were given jobs in the same establishment, but about a quarter were separated from employment -- most by clear-cut layoffs, some by quits and retirements.

Many workers were reassigned to other jobs, that is, they moved to another job that differed substantially in job content from the job previously held. This accounts for 69 percent of all the workers displaced -- 44 percent being reassigned to jobs on or in connection with the new equipment and 25 percent to jobs elsewhere in the plant. Seven percent were transferred to jobs elsewhere in the plant, at the same kind of work they had been doing, but unrelated to the new equipment.

The proportion of the establishment's workers displaced by the technological change studied was greatest in small establishments. Over-all, displacements were 2.5 percent of the total number of workers employed in the establishments at the time of the survey. But in small establishments (4-19 workers) over a third of the employees were displaced. This displacement ratio fell as establishment size rose, so that among establishments of 5,000 or more workers less than one percent were displaced.

An installation of advanced equipment in a large establishment is likely to affect only one of the units. In a small establishment it is more likely to involve the entire shop.

Separations from employment (layoffs, quits, retirements) as a percent of all displacements also were greater among small establishments than large ones. Small establishments tended to have relatively fewer transfer and reassignment possibilities.

Among the various types of equipment, metalworking machines had the lowest number of displacements -- 11 workers on the average. They are discrete pieces of equipment, and the impact of a change here may be limited to a small segment of a plant. In the cases surveyed, numerically controlled machine tools typically were used to increase metalworking capacity rather than to replace conventional machines.

Almost two-thirds of the persons displaced were in three occupation groups, for the most part at unskilled and semiskilled levels: material handlers, machine operators, and assemblers. Craftsmen, technicians, and other technical specialists accounted for relatively few of the workers who were displaced.

For the most part, the new equipment required less staff than the old, although there were a number of cases in which this did not occur. Overall, 2,261 fewer workers were needed to staff the new equipment than the old.

In the cases studied, relatively the greatest reduction in number of workers, in going from old to new equipment, occurred in connection with material handling, assembly, and packaging equipment rather than in advanced types of automation.

Staffing the New Equipment

Management drew heavily on its existing workforce in manning the new technology: 85 percent of the jobs on the new equipment were filled from internal sources, only 15 percent by new hires.

Small establishments depended far more on outside hiring to staff new equipment than did large ones.

The majority of workers who were reassigned to jobs on the new equipment had previously worked in the same general occupational field as the one to which they were newly assigned.

In the process of staffing the new equipment, over two-thirds of new and reassigned workers, according to reports of employers, were given some kind of training to help fit them for their new job. Much of this was short-term. When on-job training of one week or less is excluded, the proportion of workers receiving training drops to around one-half.

Large establishments trained somewhat higher proportions of reassigned and new workers than did small establishments.

The survey findings on characteristics of training may be summarized as follows:

- About two-thirds of the trainees received on-job rather than classroom instruction. Only 5 percent of the trainees -- concentrated in the high-skill occupations -- had classroom instruction only.

- Most of the training was done by the company that employed the worker; but in a number of instances, particularly in craft and technical occupations, it was given by the manufacturer of the new equipment.

- The bulk of classroom training was done in the plant of the employer or equipment manufacturer.

- Much of the training was of short duration: half of the trainees received instruction for one month or less. About one-third were trained for over three months.

- Training tended to be longest for equipment troubleshooters and maintenance men, equipment monitors, and other technical occupations.

- Most training given to new and reassigned workers was to supplement their existing skills rather than to train for new skills.

Skill Requirements

No widespread change in the skill level of jobs accompanied the reassignment and transfer of persons from old to new equipment in the cases covered by the present survey. Two-thirds of the workers shifted had no change. More people experienced an increase in skill level than suffered a decline:

Change in skill level	Number	Percent
All workers shifted to new equipment	2,929	100
To lower skill level	318	10
To higher skill level	610	21
No change in skill level	2,001	69

Of a total of about 5,500 workers who worked on the old equipment, the 2,929 just referred to were given jobs on the new equipment; about 1,450 were reassigned or transferred to jobs in the establishment that were not on the new equipment; and 1,100 were separated from the employ of the establishment as a result of the installation of the new equipment.

The pattern of skill level changes experienced by persons who were reassigned or transferred was determined in part by the number and sorts of job opportunity that were available on the new equipment and in part by considerations affecting managements' decisions as to which workers should get which jobs.

In part this pattern of changes also reflects the level of skill required to perform the functions of new jobs in comparison with the level required to perform similar functions in the old jobs. Analysis of this sort makes it possible to indicate how a particular function (for example, maintenance) on new equipment compares in terms of skill requirements with the same function on the replaced equipment; and, similarly, to compare skill level changes in situations where, because of mechanization, one function replaces another (for example, materials are handled by machine instead of by hand).

In the sample of cases studied, the analysis found no pronounced tendency in the direction either of an upward or of a downward change in the skill level of worker functions. When each function studied is multiplied by the number of workers involved, there is a total of 2,300 worker-functions. Of these, 429 had a downward skill-level change and 304 an upward one, while 1,567 had no change.

One of the questions to which function analysis is relevant is whether skill levels required by functions that workers perform rises as equipment becomes more highly mechanized and automated -- or whether instead the functions left to be performed by human labor need less skill than before. The third possibility -- closer to the findings of the present study -- is that the effects varied: in some cases there was little or no change in skill level, in some the level rose, and in others it fell.

Thus the cases studied suggest that there is an increase in the skill level of the troubleshooting and maintenance function where the level of mechanization rises in such a way that machines perform a sequence of functions, replacing single-function machines, and where machines capable of reacting to signals replace machines with no such capability or a limited one.

In the machine set-up function the relationship of skill level and mechanization level depends on the type of equipment. Where conventional machine tools are replaced by numerically controlled machine tools, the skill level drops, since some complicated set-up functions are, in effect, transferred to programmers. As to changes in other types of equipment, the only generalization which the cases warrant is that there is apt to be no change in set-up skill level as the level of mechanization rises, and that exceptions show upward changes.

In the case of the machine operation function, diverse tendencies prevent generalizations concerning skill level changes and level of mechanization. The new jobs were at a higher skill level where manual material handling work, simple and unskilled in nature, was replaced by palletizing and stacking equipment. On the other hand, it was lower where a machine replaced manual work requiring substantial manipulative ability, such as involved assembly and hand precision work.

The replacement of one type of machine by another was accompanied by upward skill changes in some cases and by downward changes in others; but no-change cases were numerically most important.

Diverse tendencies also characterize the relationship of the tending function skills and level of mechanization: (1) At the highest level, where monitoring a remote-control panel replaces direct machine tending or machine operation, there tends to be an increase in skill level, although in some instances there was no change. (2) At lower levels, where tending replaces machine operation -- a numerically important group of cases -- there is a pronounced downward tendency in skill level. (3) No change is characteristic where tending replaces tending. (4) Where machine tending replaces manual material handling or manual assembly work, the new job sometimes had more skill, and sometimes less, but usually there was no change among the cases studied.

The survey found that, on the whole, the education and work experience that employers required of the workers on the new jobs differed only in minor ways from those required on the old.

Need for Further Study

One reason the present survey was undertaken was to determine what might be gained from continuing study of the effects of automation and other forms of modern technology.

The results do not support the idea that major survey efforts in this field in New York State are needed on a continuing basis. There is, however, need for information about what is taking place and for alertness to problem-creating developments. With its major responsibilities for skill training and vocational education the State of New York cannot afford to be uninformed in this field.

Fortunately, the U. S. Department of Labor is devoting substantial resources to surveys of technological trends in major industries. The recent report of the Bureau of Labor Statistics on Technological Trends in Major American Industries (1966) is a valuable review of present and prospective developments, one that is to be up-dated periodically. One can also assume that university studies funded under the Manpower Development and Training Act and other studies will continue and that every now and then there will be a summing up such as the recent report of the National Commission on Technology, Automation, and Economic Progress, entitled Technology and the American Economy (1966).

What is needed in New York State is (1) a continuing familiarity with the results of research done elsewhere, (2) knowledge of what major technological changes are taking place in the State, and where, and (3) estimates of the effects of these changes on employment and skill requirements.

This suggests that the New York State Department of Labor should keep track of significant cases of advanced types of technological change taking place in New York State, as well as the results of significant research going on in this field. 1/ Special surveys then may be made from time to time, to the extent they are needed to delineate and evaluate effects in this State.

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1. The Department's Division of Research and Statistics' experience in utilizing various sources of information on technological change in New York State indicates that there is no single reliable and comprehensive source of leads. Published stories and articles describing cases of advanced automation often are misleading, tending to overstate the nature and significance of the development. In short, a great deal of effort must go into the task of running down cases meriting special study.

Chapter I

INTRODUCTION

This survey, which was made by the staff of the Labor Department's Division of Research and Statistics, with the assistance of outside engineering consultants employed on a per-diem basis, covered 281 cases of factory and related technological change in New York State. The case studies, made during the period from 1962 to 1966, covered installations begun in various years between 1958 and 1966.

The primary purpose of the study was to enlarge the existing factual base for evaluating the effects of technological change on the manpower and training needs of New York State industry.

The study was designed to identify kinds of technological change that have been taking place during the contemporary period and to help answer the following questions about the effects of these changes on employment:

(1) To what extent did changes eliminate jobs? In what occupations? What happened to the incumbents?

(2) What jobs were required by the new technology? What was the source of workers placed in these jobs?

(3) How much and what kinds of training were given to prepare workers for jobs in the new technology?

(4) How did the skills needed to perform the functions of the new technology differ from those needed before?

The study covered a sample of cases of technological change that had some effect on employment in the establishments in which they occurred. However, because it was not possible to define the universe of contemporary technological change, and because resources did not permit the searching out of all cases that could have been found, it cannot be demonstrated that the sample covered is a representative one.

The authors of the study believe that the cases covered illustrate the variety of experience and show some of the main tendencies in connection with the four sets of questions mentioned. The study should give perspective for viewing generalizations that people make about the impact of technological change on manpower needs.

Not all the figures shown in the study are equally significant. Where there are small numbers, and small differences between numbers, these should be used with caution.

Scope of Survey

The majority (about three-fourths) of the 281 cases included in the study were selected from cases reported in 1962 in connection with a study, by the Department, of technical manpower in New York State. 1/ This study, which was primarily concerned with the employment of technicians and technical specialists, covered a scientifically selected sample of New York industry, amounting to around 17,000 establishments. Each of these establishments was asked to indicate whether it had experienced technological change since 1958.

Cases in which there was an affirmative response were followed up in the field, and facts were sought from the employer on the kind of technological change and its effects on employment. A large number of the cases were dropped because the changes were found to be inconsequential or because the employer was unwilling to give the details of his experience.

About one-fourth of the 281 cases included here were ones added, in 1965 and 1966, for the purpose of enlarging the sample of recent instances of technological change. Leads to these cases were obtained in technical and trade publications and by making contact with establishments reported to have invested $1,000,000 or more in new plant and equipment during the last few years.

The result was a group of cases, including ones where the change remained within the traditional technology, as well as cases of shifts to automation and other advanced technology -- cases of both small and large employment impact -- which are illustrative of the kind and extent of technological change that has been occurring in New York State in recent years, especially in manufacturing industries.

Field work for the survey was done off and on during the period from 1962 to 1966. The field visits typically followed by two to four years the time when the technological change took place.

Manufacturing industries accounted for about 85 percent of the cases, with concentrations in the metals and machinery and food industries. About 15 percent of the cases were in nonmanufacturing industries. (Table A.)

Since 281 cases were studied in 229 establishments, it is apparent that more than one case of technological change was studied in some of the establishments. (These cases were mostly in larger plants, and involved different units of equipment.) No attempt was made, however, to include all cases of technological change taking place in the chosen establishments over any period of time. The cases studied can be described as incidents of technological change, of which there may have been several in any plant during the course of a year or two, in addition to the one or ones studied. The span of these incidents ranged from the replacement of an entire plant to the addition of a single piece of advanced equipment, or the installation on existing equipment of some type of instrumentation.

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1. New York State Department of Labor, Division of Research and Statistics, Technical Manpower in New York State (1964).

Table A. DISTRIBUTION BY INDUSTRY OF ESTABLISHMENTS AND CASES COVERED BY SURVEY

Industry	Establishments		Cases	
	Number	Percent	Number	Percent
All industries	229	100	281	100
Manufacturing, total	195	85	241	86
Durable goods industries	122	53	155	55
Primary metal	14	6	16	6
Fabricated metal products (including ordnance)	23	10	31	11
Machinery, except electrical	31	14	36	12
Electrical machinery	19	8	27	10
Transportation equipment	13	6	18	6
Instruments	12	5	14	5
Other	10	4	13	5
Nondurable goods industries	73	32	86	31
Food	25	11	31	11
Chemical	12	5	12	4
Paper	11	5	12	4
Miscellaneous manufacturing industries	9	4	11	4
Other	16	7	20	8
Nonmanufacturing, total	34	15	40	14
Service	10	5	12	4
Trade	5	2	6	2
Communication	5	2	6	2
Other	14	6	16	6

Examples of technology studied among nonmanufacturing industries included mechanization of material moving in mining and quarrying; conveyorizations in bakeries attached to a restaurant chain; installation of automatic elevators in hotels and office buildings; installations of automatic pin setters in bowling alleys; installation of automatic switching equipment in a communications business; centralization of control over the treatment of sewage in a county plant; and centralization of control over the distribution of electric power. (Appendix table I-1.)

Types of Equipment in the New Technology

For the purposes of this study, "technological change" was broadly defined to include the introduction of new equipment or new methods that resulted in the displacement of a significant number of workers, that eliminated or changed worker functions, or that modified the kinds of knowledge and skill required to perform a worker function.

For the most part these changes were small and evolutionary in nature. Despite a special effort to search them out, few cases of advanced

Table B. DISTRIBUTION OF CASES COVERED BY SURVEY, BY TYPE OF NEW EQUIPMENT

Type of new equipment	Number	Percent
All types	281	100
Automatic production lines	15	5
Process production	6	2
Automatic transfer lines and machines	9	3
Instrumentation additions	39	14
Feedback control	10	4
Other	29	10
Metalworking machinery and related equipment	105	38
Numerically controlled machine tools	44	16
Electric discharge machines	8	3
Other metal cutting machines	18	6
Riveting, welding, and soldering machines	11	4
Finishing, polishing, and sanding machines	11	4
Forming and casting machines and equipment	13	5
Mechanical material handling and moving equipment	35	12
Conveyors	20	7
Fork-lift trucks, palletizing and other equipment	15	5
Packaging and related equipment	20	7
Assembly and related equipment	20	7
Other equipment	47	17

automation involving large numbers of workers were encountered in this New York survey. There were, for example, no automated petroleum refinery plants in the State. Relatively few cases of process automation of the sort found in the chemical and paper industries are covered. Automatic production lines utilized in the production of automobile engines and parts are not represented in the survey, nor are computer-controlled steel rolling mill and related processes. Another well-publicized form of automation not represented is the use of computers in the printing industry's type-setting process.

Nevertheless, a variety of automation cases were included, as well as shifts within more traditional forms of technology.

The cases are classified in table B according to the category of the new equipment involved. 1/ These categories are detailed at the end of the chapter.

Workers Affected

On the average around 20 workers per case were affected by the technological changes included in the survey. This average number is small both

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1. New equipment was involved in all cases. However, in a few cases, the change in methodology was more significant than the change in equipment as such.

Table C. AVERAGE NUMBER OF WORKERS ASSIGNED TO THE OLD AND THE NEW EQUIPMENT, BY SIZE OF ESTABLISHMENT

Size of establishment (number of workers)	266 before-and-after cases					15 new plant and new department cases		
	Number of cases	Workers on old equipment		Workers on new equipment		Number of cases	Number of workers	Average workers per case
		Number	Average per case	Number	Average per case			
All sizes	266	5,495	21	3,330	13	15	785	52
4 to 19	8	42	5	20	3	-	-	-
20 to 49	15	134	9	77	5	1	1	1
50 to 99	15	95	6	41	3	1	5	5
100 to 199	56	770	14	424	8	1	33	33
200 to 499	65	1,194	18	613	9	5	269	54
500 to 999	49	1,531	31	760	16	1	47	47
1000 to 1999	29	873	30	741	26	4	398	100
2000 to 4999	19	443	23	308	16	2	32	16
5000 or more	10	413	41	346	35	-	-	-

because there are many small establishments in the study sample and because, typically, a small number of workers were involved in the units studied in the large establishments covered. (Table C.) The largest case involved 382 workers; the smallest, 1 worker.

Table D. NUMBER OF WORKERS ASSIGNED TO THE OLD AND NEW TECHNOLOGY, BY TYPE OF CHANGE

Type of change	Old equipment				New equipment			
	Cases		Workers		Cases		Workers	
	Number	Per-cent	Number	Per-cent	Number	Per-cent	Number	Per-cent
All types	266	100	5,495	100	281	100	4,115	100
Replacement only	211	79	4,876	89	211	76	2,704	65
Replacement and supplementation	12	5	323	6	12	4	234	6
Supplementation only	43	16	296	5	43	15	392	10
New plants and new departments	-	-	-	-	15	5	785	19

Reasons for Technological Change

The vast majority of the 281 cases -- 80 percent of them, involving 71 percent of the workers affected -- were ones in which faster, more precise, or otherwise advanced types of equipment replaced existing equipment in whole or in part. (See last columns of table D.) In about 15 percent of the cases one or more pieces of advanced equipment were added to existing equipment for the purpose of expanding existing production capacity ("supplementation only"). About half of these involved the addition of N/C machine tools to conventional ones. The remaining 5 percent of the cases involved new plants or distinctly new departments of existing plants. (See last line of table D; also second part of table C.)

Reduction in labor costs was given most often as the main reason for technological change in the cases studied. Increase in production capacity and improved quality of product ranked next in importance. (Table E.)

Table E. REASONS FOR TECHNOLOGICAL CHANGE

Reason	Order of reason given		
	First	Second	Third
All reasons - total number	281	281	281
Percent distribution			
All reasons	100	100	100
Reduce tooling costs	4	2	2
Reduce direct labor costs	60	10	5
Overcome a shortage of skilled operators	1	1	3
Reduce lead time	2	5	5
Improve product quality	8	25	9
Reduce inventory	0	0	1
Reduce floor space requirements	1	2	3
Increase production capacity	19	29	8
Accommodate a change in materials or product	2	1	1
Other	1	4	5
Not reported	2	21	58

DESCRIPTIONS OF NEW EQUIPMENT

The next pages indicate the kinds of new equipment involved in the cases included in the survey. Cases covering more than one category of new equipment as a general rule are classified on the basis of the equipment that involves the largest number of workers.

The descriptions below fall under the following main headings:

Automatic production lines
Instrumentation additions
Metalworking machinery and related equipment
Mechanical material handling and moving equipment
Packaging and related equipment
Other equipment

Automatic Production Lines

The cases classified in this group involve the introduction of machines, instruments, and other equipment to perform a series of automatic operations with little or no direct operator participation.

Process production. The six cases classified in this group involve the production of finished products by means of automatic processing of a continuous flow of materials. The materials are moved from one process to the next by pumping equipment, continuous conveyors, gravity feed, and other devices.

...Cement plants (2 cases): The production of wet-process portland cement is monitored and controlled from a central panel-board room. Involved in the process, among other kinds of equipment, are: proportional mixers that automatically weigh and selectively feed raw material into the production stream; nuclear density gauges for feedback control of slurry moisture: X-ray equipment for spectrographic analyses of raw materials; and magnetic flow meters to regulate slurry feed to the kiln. At one plant an analog computer calculates mix formulas, and TV circuits provide a view of kiln firing and feed, raw-material reclaiming, tertiary crushing, the distribution of raw material in the bins, and the placement of limestone on raw material stockpiles.

...Milk processing plant (1 case): Replaces two older plants. The processing of nine dairy products, packaged in 47 types of containers, is monitored from a central panel-board room, where the monitor also has some direct control functions with respect to the distribution of the raw milk. Fluid milk is automatically cooled as it is pumped from tank trucks to holding tanks. Volume is measured by a flow meter and a visual display indicates the level in the tanks. Fluid milk is pumped by remote control through various processes for the production of the nine products. Manual operation of pumps and valves has been eliminated.

...Chemical manufacturer (1 case): Changed from batch processing of chlorine and caustic soda using Vorce cells, to continuous processing, using mercury cells. The new process is monitored, and the valves are controlled from a central panel-board room.

...Chemical manufacturer (1 case): Changed from batch processing of silicon and zirconium tetrachloride to a continuous flow, double-distillation system. The raw material flow is controlled by a monitor at the panel board, where instruments display and record temperature, pressure, and other factors.

...Bread bakery (1 case): A new plant replaced five old installations. Pumping equipment moves flour from silos to mixer. Other ingredients for bread production are automatically metered into the mixer. After fermentation, conveyors move dough to automatic dividers and rounders; through proofing, molding, and panning; into and out of the oven; to automatic depanning machines; to a cooler; and then to automatic slicers and wrappers. Instrumentation maintains, to very close tolerances, the temperature-humidity environment and the movement of the dough through the process.

Automatic transfer lines and machines. The nine cases in this category cover machines and equipment that provide for the automatic movement of a work piece to multiple stations, with automatic performance of operations at each station. (Automatic packaging and assembly machines are not included in this group.) The transfer may be effected by the use of shuttle bars, pusher arms, conveyors, gravity feed devices, etc.

...Metalworking machine tools (2 cases): Machines drill, mill, and ream gun bolts, aluminum castings, and relay frames and armatures. One machine performs as many as 32 separate operations; the other, 12.

...Spring forming machines (1 case): Machines block, bend, and cut metal at four stations to form flat springs.

...Electrical tubing manufacture (1 case): Sliced steel is continuously fed into a tube forming machine. The tubing is automatically transferred to equipment that welds and deburrs the seam, and cuts off, straightens, washes, degreases, plates, paints, and dries the tubes.

...Electrical wire manufacture (1 case): Integrated equipment automatically draws, jackets, and color codes wire.

...Electroplating (1 case): Metal parts are automatically weighed and deposited in barrels attached to a conveyor. The barrels are transferred by conveyor for automatic, timed immersion in 23 cleansing, rinsing, and cadmium plating solutions.

...Nonferrous molding equipment (1 case): Brass and bronze plumbing fittings are sand molded on a continuous conveyor. The new equipment automatically pours and tamps sand in flask, positions and retracts metal pattern, blows away loose sand, forms a sprue for the pouring of metal (a manual operation), moves the mold for cooling, and ejects the finished casting.

...Printing and varnishing cans (1 case): Cans move through a printing, baking, and coating process automatically.

...Paper-making equipment (1 case): Paper is transferred from a calendar to a machine that slits the paper to a preset width and then to a winder that rolls it up.

Instrumentation Additions

This group includes 39 cases involving the addition of instrumentation to existing equipment and the replacement of equipment with equipment containing new or improved instrumentation.

Feedback control instrumentation. The ten cases included in this category cover instrumentation capable of measuring the actual state of a process and of using the measurements to modify the input controls. They exclude feedback control instrumentation involved in process production. Relatively simple thermostatic and "go or no-go" controls are classified as "other instrumentation."

...Beta guages (2 cases) control the thickness of rubber being fed onto tire cords and of vinyl coatings on wall coverings.

...Moisture content (1 case) of sand used in a molding process is controlled by an instrument that measures the electrical resistance in the sand and opens water valves as needed.

...Viscosity (1 case) of ink in a printing process is maintained by an instrument that controls the input of ink and solvent.

...Chemical manufacturers (2 cases) introduced instruments to measure and control such variables as density, pH, pressure, flow, level, temperature, etc., at various stages in the production of chlorine and potassium alkali.

...Generator speed (1 case) in an electric power transmission system is controlled by a comparator that measures and meshes the frequency output within the system and the frequency transmission of outside feeding systems.

...Telex equipment (1 case) automatically switches teletype messages to correct line, stores messages when all channels are busy, and retransmits them as priority permits.

...Material movement (1 case) through a kiln is controlled by instruments that select proper track.

...Temperature and humidity (1 case) in a cold storage warehouse are controlled by electronic instrumentation.

Other instrumentation (29 cases). Instruments that measure or sense environmental or operating conditions are entered in this category. They may have the capability of recording and/or displaying measurements, of signaling when the measurements exceeded preset parameters, or of reacting in a limited (go or no-go) manner. Included are:

...Electronically controlled elevators (7 cases).

...Automatic pinspotters (3 cases) in bowling alleys.

...Direct dialing and switching equipment (1 case) in a telephone system.

...Radiation gauges (1 case) to scan paper for moisture content and defects.

...Heating and air condition controls (1 case) in an office building.

...Automatic weighing machines (2 cases) that reject under-or over-weight food packages; for batching system in a metallurgical firm.

...Furnace instrumentation (2 cases) to sense and record variables in the production of steel and steel billets.

...X-ray light and refractometer (1 case) to check liquid level in cans and quality of soft drinks.

...Tape-controlled machine (1 case) for cutting paper and cardboard.

...Phototypesetters and teletypesetters (2 cases) used in newspaper printing.

...Other recording and/or control instrumentation (8 cases) to measure temperature, pressure, level, density, etc., in the manufacture of sodium perborate; amperage, weight, etc., in a titanium and iron ore grinding process; pH , stock level, alum, slurry moisture, flow, etc., in the production of paper; and relevant variables in the production of beer, in a grain milling process, in a sewage disposal system, in the dark room, processing of prints, and in the quilting of fabrics.

Metalworking Machinery and Related Equipment

The 105 cases in this group cover conventional and advanced types of metal cutting, forming, finishing, and joining machines and equipment.

Numerically controlled machine tools. This group of 44 cases includes both new and retrofitted machines. About 80 percent of the machines in the survey are equipped with point-to-point or positioning controls. The remainder, found mainly in the aero-space industries, are more complex tools, such as profilers and skin millers, with continuous path controls.

These, typically, require the use of a computer for programming. The 135 N/C machine tools reported include:

...75 drilling and boring machines;

...31 milling and profiling machines;

...17 machining centers (some of the machines classified as drills also had straight-line milling capabilities);

...13 lathes, groovers, grinders and punch presses.

Electric discharge machines. These are found in eight cases. The 11 machines are used for the most part, to make and repair dies. The discharge of electric sparks, controlled by dial settings, cuts deep slots, odd-shaped cavities, and holes at any angle to close tolerances. The process is particularly adaptable to cutting carbides and tough steels.

Other metal cutting machines. Faster, more automatic, conventional metal cutting machines, capable of operating to closer tolerances than those they replace, are found in 18 cases. The machines included are:

...20 profilers and milling machines;

...10 rotary index, multi-spindle, and turret drills;

...10 automatic turret lathes, screw machines, and multi-spindle chucking machines;

...8 disc and special purpose grinders;

...4 cut-off and deburring, broaching, and wire-cutting machines.

Welding, riveting, and soldering machines. These replace hand operated equipment in 11 cases, as follows:

...Electron beam, MIG, continuous electrode, and gas shielded arc welding machines (7 cases) are used to weld expansion tanks, drier and other shells, steel utility truck bodies, and temperature sensors. Included are dual head machines capable of welding inside and outside seams, or two shells, at the same time. In some cases, automatic equipment loads and turns the work pieces.

...Dip and flow soldering equipment (3 cases) replaces hand soldering in cases involving the production of terminal boards and electrical components.

...Automatic riveting machine (1 case) replaces hand controlled riveting guns in terminal board production.

Finishing, polishing, and sanding machines eliminate most manual operations in 11 cases, as follows:

...Polishing machines (8 cases) were installed to polish chromium plated household and other products; stainless steel sheets (with automatic lubricator), utensils, and cutlery; and hardware parts, bike brake hubs, and wire.

...Sanding machines (2 cases) replace a belt and an operator-controlled sanding machine in the finishing of machine parts, hand tools, and sheet metal.

...Finishing machine (1 case) applies a black oxide finish to gun parts. Previously the finish was applied by manually rubbing the parts with acid-impregnated cloths, humidification, and wire brushing.

Forming and casting machines and equipment account for 13 cases in the study. For the most part, they involve the installation of more automatic presses, some with automatic feed and cut-off devices. In one case a powdered metal process was installed for the production of gun parts.

...Punch presses (5 cases) automatic and semi-automatic, replace operator-controlled presses. Included is one with a motor-driven turret containing 28 punching tools.

...Forming presses (3 cases) were installed to produce switch boxes, radiators, and novelties. They replace slower, less automatic presses.

...Extrusion press (1 case) replaces a forge press in an aluminum plant.

...Powdered metal process (1 case) forms gun parts that were previously machine tooled. It involves the installation of blending, pressing, and sintering equipment.

...Casting equipment (2 cases): Centrifugal pipe casting units replace a hand-ram process in one case; in the other, molten aluminum and zinc are forced into dies by a plunger on an automatic casting machine.

...Wire flattening mill (1 case): Round wire is flattened by a double-pass mill that contains a continuous gauging device.

Mechanical Material Handling and Moving Equipment

The handling and movement of goods and materials within the production process and to and from storage areas has been and continues to be a prime target of mechanization. The equipment installed in the 35 cases studied generally replaces hand trucks, dollies, wheel barrows, and manual handling.

Conveyors. Of the 20 cases in this group, 18 involve skate and link belt, overhead chain drive, rail type, gravity, endless, and other mechanical conveyors. However, the first two cases below involve instead water and pneumatic conveying:

...Water flume (1 case) replaces a mechanical conveyor for the movement of logs.

...Pneumatic conveying system (1 case) moves polyethylene beads from railroad cars to storage silos. Previously the beads were received in bags which were manually handled.

...Assembly operations (3 cases) eliminate the handling of starter assemblies and printed circuit boards by assemblers; and move parts and materials to assembly lines.

...Bakeries (2 cases): The equipment moves goods from oven through cooling process and then to slicers and wrappers, or to trucks for delivery. It replaces manual handling.

...Warehousing (1 case): Incoming goods are moved to storage area; outgoing goods pass a control station where console operator controls the consolidation of merchandise in shipping bins by store number.

...Packaging lines (3 cases): Cartons of nuts and bolts move over automatic scales and to sealing machines; books are placed on conveyor for movement to shipping area; double-tier conveyor system replaces single-tier system for packaging milk containers.

...Production functions (9 cases): Parts and semifinished products are conveyed through degreasing operations, varnish ovens, spray painting operation, or from one operation or department to another.

Fork-lift trucks, palletizing and other equipment. These are most commonly used in the receipt or shipment of materials, products, and containers. Of the 15 cases in this category:

...Fork-lift trucks (7 cases) are used to move electrical equipment in a warehouse; to move goods to shipping areas; to move raw materials to production lines; and to move palletized bricks and masonry in a road construction operation.

...Palletizers and depalletizers (6 cases): They handle bags of salt, bags of gypsum, and cases of soft drinks and beer.

...Bulk receipt equipment (2 cases) replaces fork-lift trucks used to move bags of raw sugar and drums of chemicals to storage.

Packaging and Related Equipment

In 16 of the 20 packaging cases the machines and equipment installed replace manual operations; in the other 4 cases, faster, more automatic machines replace old models. Nine of the 20 cases are in the food industry.

Machinery replaces manual operations in the following uses:

...Weighing, sorting, and packaging eggs (1 case).

...Cap sealing and labeling bottles of wine; sealing cases (1 case).

...Boxing (5 cases): Candy; envelopes of dessert powder; bottles of shoe polish; steel wool pads; and automatic parts.

...Unfolding six-pack cartons for soda bottles (1 case).

...Casing bottles of soda (1 case).

...Bundling two one-gallon packages of ice cream together (1 case).

...Bagging and sealing or tying (4 cases): Rolls of wallpaper and toilet tissues; bedspreads, comforters and drapes; and plaster.

...Opening and closing of boxes (2 cases): Facial tissues and clamps.

One machine replaces another in the following uses:

...Casing frankfurters (1 case).

...Filling and closing cans of fruit juice (1 case).

...Packaging cream deodorant (1 case): New equipment involves change from glass jar to plastic tube.

...Packaging liquid and powder detergents (1 case): Automatic filling machines replace operator-controlled equipment.

Assembly and Related Equipment

Mechanized assembly and related operations were introduced or improved in 20 cases. Some equipment, such as automatic button sewers, is relatively conventional; other equipment contains elements of automatic transfer lines.

The more complex types of equipment do assembly automatically:

...Hose clamps (1 case): The equipment assembles the housing and slotted band, drives a screw on the housing to a preset diameter, and ejects the finished clamp. Previously, discrete machine and manual operations were required.

...Meter parts (1 case): The equipment cements, drills ring, and solders. Nonautomatic machines were replaced.

...Rivet and eyelet case assemblies (1 case): The equipment builds up bearing assembly for end of motor and rivets assembly to end plate. Previously bearings were hand assembled and manually riveted.

...Printed circuit boards (2 cases): The equipment inserts components (resistors, capacitors, sockets, etc.) into boards (previously assembled by hand).

...Condensers (1 case): The equipment replaces manual sub-assembly and power press for final assembly.

...Cartons (2 cases): The equipment folds, feeds, and glues. Cartons were formerly folded by hand and then glued by machine.

Other machines assemble or assist in the assembly of the following:

...Garments (3 cases): The machine automatically places and sews buttons on apparel. Previously the buttons were hand sewn.

...Dolls (2 cases): The equipment heats plastic parts, spreads holes in body, fills dolls. In conjunction with the installation of new equipment in one case, a procedural change makes each manual assembler responsible for the complete, rather than partial, doll assembly.

...Motor field coils (1 case): Machines replace hand winding.

...Hair rollers (1 case): The machine cuts and inserts brush in roller.

...Pens (2 cases): Hand assembly of three parts of pen is replaced by automatic machine assembly. This eliminates hand positioning and two machine operations for crimping and swaging caps on markers.

...Zippers (1 case): Automatic machines replace operator-controlled machines for the assembly of zipper parts and components.

...Handbags (1 case): The new equipment attaches handles to bags and performs other assembly operations.

...Shirt collars (1 case): The new equipment fuses stays to collars. Stays were previously manually inserted in patches stitched on collars.

Other Equipment

This miscellaneous group of 47 cases includes machines and equipment which do not clearly fall within the scope of the major categories. They cover such diverse technologies as:

...Spray painting machines (5 cases) for dolls, bicycles, machines, and other products.

...Video tape machines (5 cases) to replace filming of television shows.

...Bakery equipment (4 cases) to pump flour, roll and deposit dough, unload pans, continuously mix ingredients, etc.

...Woodworking machines (2 cases) to cut and plane boards and to recess door hinges.

...Rotary drills (2 cases) to replace churn drills in quarries.

...Wire winding machines (2 cases) to replace manual winding and obsolete rewinding machines.

...Candy molding machines (2 cases) for hard and soft candies.

...Die clicking machines (2 cases) to cut cloth for men's apparel.

...Laundry equipment (2 cases) for ironing flat work (automatic feed) and for pressing the front and back of a shirt simultaneously.

...Automatic centrifugal machines (1 case) for sugar refining.

...Coke ovens (1 case) of improved design and with increased capacity.

...Fourdrinier paper machine (1 case) to replace three cylinder paper machines.

...Other equipment (2 cases) to trim sheets of paper; fill, weigh and move abrasive molds; pelletize aspirins; extrude plastic insulation and jackets on wire; form cosmetic powder tablets; make ice cream stick novelties; bevel glass mirrors; pump molten metal; chip bark off logs; adjust electrical relays; blow mold and process doll bodies and legs; apply porcelain glazing; vacuum press prune juice; and vinyl coat fishing lines.

Included in this group were workers whose primary function was attending to the operation of N/C machine tools. All were classified as "N/C machine tool attendants." In a few cases such attendants might have been classified as craftsmen because they had the responsibility of proving out the program, a function normally performed by toolmakers, programmers, or foremen. In some cases, attendants were occasionally required to operate the N/C machines in manual control.

Machine operator (15 percent of total). Primary responsibility is the manual and manipulative operation, guidance, and control of a machine (other than vehicle). Class A as well as less skilled machine operators are included in this group.

Vehicle operator (3 percent of total). This group includes operation of fork-lift and other kinds of trucks, vehicles, and cranes used in material moving.

Maintenance man (13 percent of total). The primary responsibility is diagnosis of malfunctions, preventive maintenance, and repair of machines and equipment, including electrical, mechanical, electrical-electronic, electromechanical, instrument, and hydraulic maintenance. (Troubleshooting of complex equipment was included in technical occupations.)

Technical occupations (10 percent of total). This group is primarily composed of technicians in a variety of fields, including those engaged in programming for numerically controlled machine tools, industrial engineering technicians and methods men, draftsmen, radio operators, and troubleshooters of complex electronic and other equipment.

Semiskilled operative, n.e.c. (about 1 percent of total). This is a miscellaneous group of semiskilled occupations that do not fall in specified machine operator and other essentially semiskilled groups. Included are hand spray painters, solderers, bakery scalers, milk receiving operators, metal pourers, mercury recovery operators, and other miscellaneous special occupations.

Service occupations (about 1/2 of 1 percent of the total). This group includes some workers in a few cases involving service operations -- mainly elevator operators and starters and bowling pin boys and chasers.

Material handler (14 percent of total). The primary responsibility of this group is the moving of materials and products by manual means. It includes general laborers (including cleanup), machine operator helpers, hand packing and packaging, and machine feeding and offbearing (removing the output of machines).

Other occupations (1 percent of total). This group mainly includes foremen and other supervisory workers and professional engineers and chemists. Most such personnel were excluded on the ground that in the present survey they were involved to only a limited, partial extent with the new equipment.

Table M shows both presence and absence of occupational concentration on particular kinds of equipment. Technical and maintenance occupain set-up, programmers, and other kinds of personnel devoted to preparing the equipment for production or in maintaining it in working order. Generally speaking, only personnel directly associated with new equipment in these ways were included. But also included were persons whose functions were continued from the previously existing equipment, especially material handlers.

Most supervisory and professional personnel were excluded from the figures as not being directly and solely concerned with the new equipment. Those who were included are classified under "other occupations" in the tables.

It is apparent that the span of operations performed by the new equipment and the structure of work organization has a bearing on the size and kind of staff it required. For example, troubleshooting and maintenance work is commonly performed by representatives of the equipment manufacturer, especially in the case of numerically controlled (N/C) machine tools and other highly instrumented equipment. And N/C programming work may either be done in the N/C unit, done elsewhere in the firm, or contracted out to a service agency. Similarly, tool and die making may be done within a machine tool unit or subcontracted out to another business firm.

Following are brief descriptions of the occupations found on the new equipment:

Assembler (4 percent of all workers). Primary responsibility is the manual putting together of a product or product parts. Work usually includes use of hand and powered tools.

Craftsman (8 percent of all workers). This group includes various types of traditional craftsmen other than those engaged primarily in maintenance work (see below), notably tool makers, machine set-up men, all-around machinists, skilled welders, molders or casters, millwrights, skilled bakery workers, and printers.

Clerical occupations (7 percent of all workers). This group includes typists, teletypists, teletype setters, telephone operators, and certain other clerical personnel used in such operations as telephone exchanges, tape preparation for numerically controlled machine tools, and communication systems.

Inspector and tester (1 percent of all workers). Primary responsibility is inspection and testing of raw materials and products for defects.

Machine and equipment attendant or monitor (24 percent of all workers). Primary responsibility of attendants is the direct observation of a mechanical process or machine and turning off, and possibly adjusting, an automatic process or machine in the event of malfunction.

The monitor watches over dials and other measuring and signaling devices or instruments and turns off, and possibly adjusts, an automatic process or machine in the event of malfunction. Work may involve pressing buttons or pulling levers to control or alter flow of objects or materials. Monitoring may be at a point removed from actual processes (remote control monitor).

Source	Number	Percent
All sources	4,115	100
Reassigned	2,646	64
From old equipment replaced	1,983	48
From elsewhere in plant	663	16
Transferred	970	24
From old equipment replaced	953	23
From elsewhere in plant	17	1
Hired	499	12

As might be expected, small establishments depended more on outside hiring than did large ones. The figures in the first column of figures below show what percent of the new equipment staff were new hires in establishments of various sizes. When the 15 cases involving a new plant or a new department are omitted from the calculation, in the second column, the relative importance of new hires in smaller establishments comes out even more clearly:

Size of establishment	All cases	Limited cases (a)
All sizes	12%	6%
4- 19 workers	20	25
20- 49	13	15
50- 99	22	16
100- 199	12	17
200- 499	32	1
500- 999	7	3
1000-1999	5	7
2000-4999	2	1
5000 or more	3	4

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a. Excludes cases in which a new plant or a new department was created.

Composition of Staff

A wide variety of occupations were involved in operating and servicing the new equipment. Appendix table III-1 gives a composite picture of these occupations, along with the sources of workers in each occupation.

Table M shows how occupational patterns vary by type of new equipment.

Considered as part of the staff were all workers who operated or in some manner served or serviced the new equipment. Besides operators, attendants, monitors, and other personnel directly involved in operation, these included maintenance workers, troubleshooters, toolmakers, personnel engaged

Table M - continued

B. Percent Distribution

Type of new equipment	All occupations	Assemblers	Craftsmen	Clerical occupations	Inspectors and testers	Machine and equipment attendants and monitors	Machine operators	Vehicle operators	Maintenance men	Technical occupations	Semi-skilled operatives, n.e.c.	Service workers	Material handlers	Other occupations
All types	100.0	3.5	8.0	7.0	0.9	17.4	21.3	3.1	12.8	9.6	0.7	0.5	14.0	1.2
Automatic production lines	100.0	0.1	6.4	1.7	-	24.7	15.2	8.3	15.6	1.7	2.0	-	21.7	2.6
Process production	100.0	0.2	7.5	2.1	-	27.6	3.4	9.3	18.9	2.1	2.5	-	23.2	3.2
Automatic transfer lines and machines	100.0	-	2.2	-	-	12.3	63.1	4.3	2.2	-	-	-	15.9	-
Instrumentation additions	100.0	-	5.5	22.0	-	15.5	14.0	-	20.2	17.3	0.2	1.3	3.4	0.6
Feedback control	100.0	-	0.7	26.8	-	4.3	18.7	-	26.6	22.6	0.2	-	0.1	-
Other	100.0	-	16.9	10.8	-	42.2	2.9	-	5.0	4.7	-	4.4	11.1	2.0
Metalworking machinery and related equipment	100.0	6.0	12.5	1.9	-	1.2	46.9	-	10.9	15.0	-	-	4.0	1.6
Numerically controlled machine tools	100.0	-	12.6	3.4	-	-	50.6	-	9.9	21.3	-	-	-	2.2
Electric discharge machines	100.0	-	57.9	-	-	-	31.6	-	10.5	-	-	-	-	-
Other metal cutting machines	100.0	-	7.5	-	-	-	82.0	-	7.5	-	-	-	3.0	-
Riveting and welding machines	100.0	36.7	19.7	-	-	4.1	4.8	-	14.3	18.4	-	-	-	2.0
Finishing, polishing, and sanding machines	100.0	-	2.0	-	-	6.1	81.7	-	4.1	-	-	-	6.1	-
Forming and casting machines and equipment	100.0	-	2.7	-	-	1.8	52.2	-	15.9	-	-	-	27.4	-
Mechanical material handling and moving equipment	100.0	3.8	-	-	0.4	24.8	2.1	12.3	2.3	-	-	-	54.3	-
Conveyors	100.0	5.9	-	-	0.7	7.9	1.3	5.2	3.0	-	-	-	76.1	-
Fork lift trucks, palletizing and other equipment	100.0	-	-	-	-	54.7	3.4	24.7	1.1	-	-	-	16.1	-
Packaging and related equipment	100.0	-	0.5	-	11.4	50.2	8.5	-	4.3	-	-	-	23.2	1.9
Assembly and related equipment	100.0	38.8	1.1	-	-	20.2	29.8	-	6.4	-	-	-	3.7	-
Other equipment	100.0	-	22.4	-	1.9	19.0	21.7	2.5	11.0	10.3	2.3	0.8	7.0	1.1

Table M. DISTRIBUTION OF WORKERS ON NEW EQUIPMENT BY TYPE OF EQUIPMENT AND OCCUPATION

A. Number

Type of new equipment	All occupations	Assemblers	Craftsmen	Clerical occupations	Inspectors and testers	Machine and equipment attendants and monitors	Machine operators	Vehicle operators	Maintenance men	Technical occupations	Semi-skilled operatives, n.e.c.	Service workers	Material handlers	Other occupations
All types	4,115	146	331	286	35	716	879	129	526	397	27	19	576	48
Automatic production lines	699	1	45	12	-	172	106	58	109	12	14	-	152	18
Process production	561	1	42	12	-	155	19	52	106	12	14	-	130	18
Automatic transfer lines and machines	138	-	3	-	-	17	87	6	3	-	-	-	22	-
Instrumentation additions	1,163	-	64	257	-	180	163	-	235	201	2	15	39	7
Feedback control	820	-	6	220	-	35	153	-	218	185	2	-	1	-
Other	343	-	58	37	-	145	10	-	17	16	-	15	38	7
Metalworking machinery and related equipment	901	54	113	17	-	11	423	-	98	135	-	-	36	14
Numerically controlled machine tools	506	-	64	17	-	-	256	-	50	108	-	-	-	11
Electric discharge machines	19	-	11	-	-	-	6	-	2	-	-	-	-	-
Other metal cutting machines	67	-	5	-	-	-	55	-	5	-	-	-	2	-
Riveting and welding machines	147	54	29	-	-	6	7	-	21	27	-	-	-	3
Finishing, polishing, and sanding machines	49	-	1	-	-	3	40	-	2	-	-	-	3	-
Forming and casting machines and equipment	113	-	3	-	-	2	59	-	18	-	-	-	31	-
Mechanical material handling and moving equipment	479	18	-	-	2	119	10	59	11	-	-	-	260	-
Conveyors	305	18	-	-	2	24	4	16	9	-	-	-	232	-
Fork lift trucks, palletizing and other equipment	174	-	-	-	-	95	6	43	2	-	-	-	28	-
Packaging and related equipment	211	-	1	-	24	106	18	-	9	-	-	-	49	4
Assembly and related equipment	188	73	2	-	-	38	56	-	12	-	-	-	7	-
Other equipment	474	-	106	-	9	90	103	12	52	49	11	4	33	5

Continued

Chapter III

STAFFING THE NEW EQUIPMENT

This chapter sets forth the survey's findings on the occupational composition of staff assigned to the new equipment and indicates from where these employees were drawn and the role played by training and retraining in the staffing process.

Sources of Workers

For the most part, in the cases studied, management utilized its existing work force to man the new technology: 88 percent of the jobs on the new equipment were filled from internal sources, 12 percent by new hires. [1]

Almost two-thirds of the workers were reassigned from previous jobs -- that is, in shifts involving substantial changes in job content. Most (48 percent of the total of workers on the new equipment) were reassigned from jobs on the old equipment.

About a quarter of the workers were transferred, that is, were shifted from old equipment without any change or any significant change in job content.

Of the nearly 500 new hires shown in the following analysis of sources, two-thirds were in the 15 cases in which new plants were built or distinctly new departments of existing plants were set up to operate new equipment.

For the figures, see page 36.

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1. The staff reported in this chapter to be working on new equipment is the number as of the time of the survey, which, as previously indicated, followed the date of the new equipment installation by two to four years. The jobs reported as filled by transfers and reassignments from old equipment replaced, however, were those filled in this manner at the time the new equipment was first staffed, regardless of whether or not the same people held these jobs at the time the survey was made. Jobs reported as filled by hiring and jobs reported as filled by transfers and reassignments from elsewhere in the plant include those filled in these ways at the time the new equipment was staffed plus (or minus) jobs that were added and filled in these ways (or jobs eliminated) between the time the new equipment was installed and the time the survey was made. Thus the number of new hires and the number of transfers and reassignments from units of the plant other than staff that worked on the old equipment was influenced by the expansion (or contraction) in the workforce between the time of the installation and the survey.

Note that the hires on new equipment are not the total number of hires that resulted from the technological change; for positions vacated when persons were transferred or reassigned to the new equipment from units of the plant other than staff of old equipment were filled by new hires.

The net change being less in the more advanced types, these data give no support to the idea that the displacement effects of advanced types of automation are more severe than changes within the field of conventional equipment. On the contrary, the highest displacement rates listed relate to conventional types of equipment for assembly, packaging, and material handling. 1/

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2 (from previous page). The reader should bear in mind that the number of workers on new equipment used in this report is the number on the date of the survey, which typically followed by two to four years the time that the shift to new equipment took place. If the work force of the establishment increased or decreased in the interval, it is possible that the number of workers on the equipment studied did so too -- probably more often an expansion than a contraction, since this was a period of generally rising production. Also, see the footnote on page 33.

1. This conclusion seems warranted even if one makes allowance for the possibility that any expansion in employment between the time of the installation and the time of survey (referred to in the previous footnote) was substantially greater on the advanced than on the conventional type of equipment.

Table L. DIFFERENCES IN WORK FORCE REQUIREMENTS FOR OLD AND NEW EQUIPMENT, BY TYPE OF EQUIPMENT

(223 cases involving total or partial replacement of existing equipment)

Type of new equipment	Total workers				Number of dis-placements	Net change as percent of dis-placements	Separ-ations	New hires	Separ-ations less new hires
	On old equip-ment	On new equip-ment	Net change						
			Number	Per-cent					
All types	5,199	2,938	-2,261	-43	4,345	52	1,101	164	937
Automatic production lines	565	383	- 182	-32	456	40	123	48	75
Process production	424	290	- 134	-32	325	41	117	48	69
Automatic transfer lines	141	93	- 48	-34	131	37	6	-	6
Instrumentation	1,104	710	- 394	-36	785	50	313	46	267
Feedback	492	422	- 70	-14	228	31	116	37	79
Other	612	288	- 324	-53	557	58	197	9	188
Metalworking machinery and related equipment	914	537	- 377	-41	876	43	53	35	18
Numerically controlled machine tools	338	239	- 99	-29	303	33	5	24	- 19
Electric discharge machines	6	6	-	-	6	-	-	-	-
Other metal cutting machines	121	59	- 62	-51	120	52	4	4	-
Riveting, welding, and soldering machines	164	79	- 85	-52	164	52	14	3	11
Finishing, polishing, and sanding machines	111	49	- 62	-56	109	57	4	2	2
Forming and casting machines and equipment	174	105	- 69	-40	174	40	26	2	24
Mechanical material handling and moving equipment	984	473	- 511	-52	763	67	248	8	240
Conveyors	447	299	- 148	-33	256	58	39	6	33
Fork-lift trucks, palletizing and other equipment	537	174	- 363	-68	507	72	209	2	207
Packaging and related equipment	383	195	- 188	-49	319	59	87	11	76
Assembly and related equipment	440	186	- 254	-58	406	63	147	-	147
Other equipment	809	454	- 355	-44	740	48	130	16	114

The data in this section cover the 233 cases in which the new equipment wholly or partly replaced the old equipment; they omit the remaining 48 cases, in which the new equipment served solely to supplement existing equipment.

Except in a few cases, 1/ there were fewer employees after the change, in the unit involved, than there were before.

Data relating to the net change -- by type of equipment -- will be found in table L. All 233 cases taken together show a drop of 43 percent in the number of employees:

On old equipment there were	5,199
On new equipment there were	2,938
Net reduction	2,261

Of the 5,199 workers on the old equipment, 2,554 were eliminated -- 1,101 by separation and 1,453 by transfer and reassignment elsewhere in the plant (not to the new equipment). The 2,938 workers on the new equipment are composed of 2,645 workers who were transferred or reassigned from the old equipment, supplemented by 164 new hires and 129 transfers and reassignments from elsewhere in the plant.

The net figure -- 2,261 -- is only 52 percent as large as the gross figure of 4,345 displacements in the 233 cases involved here. In the various types of equipment, the percent relation between net and gross change ranges from 31 percent in the case of feedback instrumentation to 72 percent in the case of fork-lift and related mechanization. (Column 6 of table L.) 2/

Over-all, the net reduction is 43 percent (from 5,199 to 2,938). The percent reduction for the various types of equipment are as follows:

Advanced types:	
Feedback instrumentation	14
N/C machine tools	29
Automatic production lines	32
Conventional types:	
"Other equipment"	44
Metalworking other than N/C	48
Packaging equipment	49
Mechanical material handling	52
Instrumentation other than feedback	53
Assembly equipment	58

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1. In a few cases there were more workers, or the same number, after the technological change. This does not mean that the firm, in making the change, failed to reduce labor costs per unit, for in many of the cases studied the new equipment expanded the productive capacity of the operation. This was generally true, for example, of numerically controlled machine tool installations. Similarly, in some instances the desire to improve product quality -- by more precise machining, for example -- was a factor in the change. See also the next footnote.

2. See page 32.

unskilled and semiskilled levels:

Material handlers -- 31 percent
Machine operators -- 23 percent
Assemblers -- 9 percent

Lower-skill workers account for three-quarters of all displaced workers if to these three occupations are added elevator operators, miscellaneous semi-skilled workers, and machine attendants (Table K, second column.)

All these occupations -- except machine operators -- had an above-average ratio of separations to total displacements. (Table K, third column.)

In the skilled and technical worker category, craftsmen account for the largest proportion of workers displaced. (They are 8 percent of all workers displaced). They have no separation ratios.

The relatively high separation rate of material handlers and assemblers reflects a large displacement of workers by labor-savings devices and a comparatively small number of suitable jobs on new equipment to which they could be transferred or reassigned. The low separation rate of metalworking machine operators is explained by factors brought out in the earlier discussion of metalworking machine displacements -- the relatively low average number of workers displaced, the relatively large establishment size, and the relatively frequent use of new equipment to supplement existing capacity.

About 40 percent of the machine attendants separated were accounted for by the installation of a more automatic chemical manufacturing process in a sizeable upstate plant. Most of the remaining attendants separated were persons who quit their jobs in two food manufacturing operations which were shifted from an existing plant to a new, more modern plant at another location. The workers decided against moving to the new location.

The elevator operator cases in the survey included three office buildings, two hotels, and two industrial plants. To the extent they took place, the shifts of displaced workers in the office buildings were to starter, porter, handyman,or maintenance jobs. In hotels, they were to maids' jobs, and in the industrial establishments they were to various manual occupations. For the most part, however, opportunities for reassignment within the establishments that installed automatic elevators were severely limited by the small number of suitable jobs available.

Net Change in Number of Jobs

So far, this chapter has been concerned only with jobs eliminated when new equipment was installed. The present section, in comparing the number of jobs in the unit before and after the technological change, will bring into the picture workers added by new hires and workers brought in from elsewhere in the establishment, and so present the net change in the number of jobs that accompanied the installation of the new equipment.

Table K. DISTRIBUTION OF DISPLACED WORKERS, BY OCCUPATION GROUP

Occupation group	Displaced workers		Separations as a percent of displaced workers
	Number	Percent	
All occupations	4,542	100	24
Material handler	1,431	31	28
Feeder-offbearer	427	9	26
Hand packer	275	6	25
General laborer	211	5	41
Other material handlers, n.e.c.	518	11	25
Machine operator	1,045	23	10
Metalworking machine operator	565	12	7
Other machine operator, n.e.c.	480	11	14
Assembler	419	9	35
Craftsman	354	8	4
Printing craftsman	100	2	7
All-round machinist	66	1	-
Toolmaker.	54	1	4
Other craftsman, n.e.c.	134	4	4
Attendants and monitors, machine and equipment	302	7	30
Service occupations	251	6	76
Elevator operator	226	5	75
Other service worker	25	1	88
Maintenance man	218	5	22
Semiskilled operative, n.e.c.	201	4	28
Technical occupations	173	4	7
All other occupations, n.e.c.	148	3	28

The last column of table I shows the ratio of separations to total displacements by type of new equipment. The relatively large group of metalworking machines had separation ratios far below the average. One reason for this, already referred to, is that these cases were in relatively large establishments, which meant a good chance to transfer or reassign workers. Another reason is that to a greater extent than in other groups of cases the new equipment was used to supplement existing capacity, thus maintaining or expanding the need for machine tool operators. Numerically controlled machine tools typically were used to increase metalworking capacity, as well as to cut costs and increase the quality of the work done.

Occupations 1/ of Displaced Workers

In the cases surveyed, almost two-thirds of persons displaced by technological change were in three occupation groups, for the most part at the

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1. See chapter III for description of occupation groups.

Table J. SUMMARY OF DISPLACEMENTS AS A PERCENT OF ESTABLISHMENT EMPLOYMENT

Type of new equipment	Average employment per establishment	Average workers displaced per case	Displacements as percent of employment
All types	708	17	2.5
Automatic production lines	1,418	38	2.7
Metalworking machines	1,183	11	0.9
Instrumentation	1,080	22	2.0
Mechanical material handling	652	23	3.5
"Other equipment"	614	17	2.8
Assembly equipment	606	20	3.4
Packaging equipment	250	16	6.5

resulted in the layoff of 21 of the 24 pinsetters. In another case, a small welding shop installed an automatic welding machine that did the work formerly requiring three hand welders. Accordingly, in the smallest establishments -- those with 4-19 employees -- about 70 percent of the workers displaced by technological change were separated from employment, counting layoffs, quits, and retirements. In contrast, in the largest establishments -- 5,000 or more workers -- no workers were reported as having been separated. (See last column of table H.) The declining ratio of separations to total displacements tends to hold true for each type of new equipment. (Appendix table II-2.)

Displacement and Types of New Equipment

The figures in the first column of table I show that advanced forms of equipment -- automatic production lines, feedback instrumentation, numerically controlled (N/C) machine tools, and electric discharge machines -- account for around 25 percent of all displacements recorded in the survey. Other forms of instrumentation and of metalworking machines account for 26 percent, and material handling, packaging equipment, and assembly equipment for 33 percent.

The second column of table I shows that in the largest group -- metalworking machines -- 11 workers were displaced, on the average. The average was substantially larger in the case of automatic production lines, material handling, and instrumentation and somewhat larger in the case of packaging and assembly. These extreme differences are explained in part at least by the fact that metalworking machines are discrete pieces of equipment whose impact may be limited to a small segment of a plant, whereas process production and related forms of automation are more likely to affect workers in an entire production unit or department of a plant.

Not only are changes related to metalworking machines often limited to a small segment of the plant, but the establishments involved were above-average in size. As a result, in the average metalworking machine case the displacements are only about 1 percent of total employment, well below the other categories. (Table J.)

Table I. NUMBER OF DISPLACED WORKERS, BY TYPE OF NEW EQUIPMENT

Type of new equipment	Number of workers displaced: Total	Number of workers displaced: Average per case	Displacements as a percent of total employment	Separations as a percent of total displacements
All types	4,542	17	2.5	24
Automatic production lines	457	38	2.7	27
Process production	326	65	8.7	36
Automatic transfer lines and machines	131	19	1.0	5
Instrumentation additions	793	22	2.0	39
Feedback control	236	26	6.0	49
Other control	557	21	1.6	35
Metal working machinery and related equipment	1,056	11	0.9	5
N/C machine tools	449	11	0.6	1
Electric discharge machines	12	2	1.4	0
Other metal cutting machines	124	7	0.8	6
Riveting and welding machines	188	19	1.7	7
Finishing, polishing, and sanding machines	109	10	2.1	4
Forming and casting machines and equipment	174	16	2.1	15
Mechanical material handling and moving equipment	763	23	3.5	33
Conveyors	256	14	1.9	15
Fork-lift trucks, palletizing and other equipment	507	34	6.5	41
Packaging and related equipment	326	16	6.5	27
Assembly and related equipment	407	20	3.4	36
Other equipment	740	17	2.8	18

4-19 workers, 35 percent of the establishment's total employees were displaced. In contrast, about 1 percent were displaced in establishments with 1,000 or more employees. (Table H.) [1]

Small size limits transfer and reassignment possibilities and makes layoff more likely. This is suggested by three bowling alley cases included in the survey, in which the installation of automatic pin-setting equipment

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[1] The technological displacement rates for large plants may be understated, since typically the survey covered one technological change -- out of possibly several that may have taken place during the course of the year.

Table H. NUMBER OF DISPLACED WORKERS BY ESTABLISHMENT SIZE

Size of establishment (number of workers)	Number of workers displaced		Displacements as a percent of total employment(a)	Separations as a percent of total displacements
	Total	Average per case		
All sizes	4,542	17	2.5	24
4 - 19 workers	39	5	34.8	69
20 - 49 workers	110	7	25.6	55
50 - 99 workers	87	6	8.1	44
100 - 199 workers	649	12	10.3	34
200 - 499 workers	1,061	16	6.1	21
500 - 999 workers	1,287	26	5.3	31
1,000 - 1,999 workers	515	18	1.6	24
2,000 - 4,999 workers	394	21	1.0	2
5,000 or more workers	400	40	0.6	0

a. The comparisons of number of displacements and total employment are not precise because different time periods were involved in some cases -- total employment being as of the time of the survey visit, which may have followed by one or more years the period in which the displacements occurred. It is probable that because of rising employment trends, this disparity in time has the tendency to understate the displacement ratios.

was one of generally rising production activity, 1/ the number of jobs found to have been eliminated probably was less than the number that would have been found had the economy been in a static or declining phase.

Displacement and Establishment Size

Judging by the sample covered in the present survey, the number of workers displaced (jobs eliminated) in a typical case of technological change was small. The average displacement in all cases was 17 workers. Even in establishments of 5,000 employees or more, the average was only 40. (Table H.)

Displacements were 2.5 percent of the total number of workers employed at the time of the survey, in the establishments covered. However, an installation of advanced equipment in a large establishment is likely to affect only a unit of workers, whereas in a small establishment the entire shop is more likely to be involved when a technological innovation takes place. Accordingly, in the average case involving an establishment with only

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1. The New York State Business Activity Index of the New York State Department of Commerce rose by 15 percent from 1958 to 1962 and by 16 percent from 1962 to 1966. Factory output rose by 18 percent and 20 percent in the two periods.

When jobs were eliminated, the incumbents were either separated, reassigned, or transferred. Reassignment was by far the most frequent disposition of workers. (Table F and appendix table II-1.)

Loss of job -- separation from employment -- occurred in the case of 24 percent of the workers whose jobs were eliminated. Most (807) were clear-cut layoffs, but some (297) were reported as quits and retirements. It was not always possible to tell, however, whether the reported quits and retirements were in fact voluntary and so distinguishable from layoffs.

In 76 percent of the cases there were no separations. Half of the 1,104 separations occurred in the 3 percent of the cases that involved 50 or more separations; 14 percent of the cases involved fewer than 10 separations. (Table G.)

Table G. DISTRIBUTION OF SEPARATIONS FROM EMPLOYMENT
(EXCLUDES NEW PLANT AND NEW DEPARTMENT CASES)

Number of separations per case	Cases		Workers separated	
	Number	Percent	Number	Percent
All cases	266	100	1,104	xx
No separations	201	76	xx	xx
One or more, total	65	24	1,104	100
1 to 3	20	7	46	4
4 to 9	19	7	114	10
10 to 19	9	3	118	11
20 to 49	10	4	292	26
50 or more	7	3	534	49

In this study, a worker is classified as reassigned if he was moved to a job with a substantially different content. Most of these people were shifted to jobs directly connected with the new equipment; the rest to jobs elsewhere in the plant.

A worker is here classified as transferred if he was shifted to a job in another section of the plant, unrelated to the new equipment, without any substantial change in his job duties. As previously indicated, a worker whose transfer was to the new equipment rather than to a different section of the plant was not considered to have been displaced, since there was no significant change in his job responsibilities (even though he was working on different equipment and doing slightly different sorts of things).

In analyzing the displacement effects of the new equipment installations no adjustments were made in the data for changes in the volume of operations carried on by the businesses studied. Since the period surveyed

Chapter II

DISPLACEMENT OF WORKERS

This chapter presents the survey's findings with respect to the effects of technological change in displacing workers. It deals with what happened to the workers displaced.

The analyses in the first sections of the chapter are in terms of the number of jobs eliminated by the technological changes. This refers to a gross change (see reference to net change, just below). Each job eliminated meant one worker displaced. While some displaced workers were permanently laid off by the employing company, others were shifted within the establishment (see the next section, on types of displacement). These shifted workers include persons put to work on the new equipment, provided that they were reassigned to a job with substantially different duties; if a worker was instead transferred to a job on the new equipment without a change in the kind of work he did, his job was not classified as eliminated.

Table F. DISPOSITION OF DISPLACED WORKERS

Disposition	Number of workers	Percent
All distributions	4,542	100
Separated (layoff, quit, retirement)	1,104	24
Reassigned	3,106	69
To new equipment	1,983	44
Elsewhere in plant	1,123	25
Transferred elsewhere in plant	332	7

The final section of the chapter will deal with the net change in the number of jobs when technological changes were introduced. It takes into consideration the firm's need for manpower to staff the new equipment. An example is a case where a machine operator in the changed unit was reassigned to substantially more difficult duties on a new piece of equipment in that same unit. The elimination of his old job was offset by the creation of his new one, so that there was no net change in the number of jobs in the unit.

Types of Displacement

One or more jobs were eliminated in 259 of the 266 cases studied. (Fifteen cases involving new plants or new departments are excluded.) Altogether, 4,542 jobs were eliminated in these cases.

tions and "other occupations" (supervisors, engineers, chemists) are heavily concentrated in advanced types of equipment -- automatic production lines, instrumented equipment, and numerically controlled machine tools. Clerical personnel are primarily teletypists in the instrumentation category; those in the N/C category, primarily persons preparing N/C tape. Service workers working with instrumented equipment are elevator starters.

Material handlers, machine operators, machine attendants and monitors, assemblers, vehicle operators, and craftsmen are more widely dispersed among the various types of new equipment. While to a large extent persons in these occupations work directly on the new equipment, some do so only indirectly. For example, manual material handlers were reported on nearly all categories of equipment; relatively large numbers of them were engaged in moving materials to an automatic production line and taking its product away. Similarly, vehicle operators -- fork-lift truck and crane operators -- were found involved in automatic production line operations. Another example is a group of assemblers working in connection with conveyors, the technological change being a conveyor installation in connection with an assembly operation.

Machine attendants and monitors emerged as an important group of occupations in the present study. They are encountered on highly mechanized equipment -- on packaging equipment, conveyors, and other material handling equipment, as well as on automatic production lines, numerically controlled machine tools, and other instrumented equipment. Tending functions replaced machine operation and manual material handling functions, in a number of cases studied (described in Chapter IV, in connection with the subject of skill-level changes).

Previous Occupations

The majority of workers who were reassigned to jobs on the new equipment had previously worked in the same general occupation field as the one to which they were assigned on the new equipment. (Appendix table III-2.)

Table N shows that it was a very large majority in some cases; but that persons reassigned to jobs as machine attendants and monitors and as vehicle operators were at the other extreme -- they had rarely been in that general field before. Some of these persons had instead held such jobs as assembler, machine operator, maintenance man, and material handler.

These reassignments all involved substantial changes in job content. They did not, however, necessarily result in a change in skill level, upward or downward. The subject of skill-level change is taken up in chapter IV.

Training and Retraining

In the process of staffing the new equipment, two-thirds (68 percent) of the newly hired and reassigned workers, according to reports of employers, were given deliberate instruction either on the job or in a classroom to help fit them for their new jobs. This excludes any incidental training that was

Table N. PREVIOUS OCCUPATIONS OF WORKERS REASSIGNED TO NEW EQUIPMENT

Present occupation or group	Proportion of workers whose previous job was in same occupation group	Other previous occupation groups
Assembler	100	--
Craftsman	90	machine operator; clerical (printing industry)
Clerical occupations	99	--
Inspector and tester	32	material handler
Machine and equipment attendants	17	assembler; machine operator; material handler
Machine and equipment monitors	14	machine operator; maintenance man
Machine operator	55	--
Metalworking machine operator	76	craftsman; material handler
Other machine operators	40	material handler
Vehicle operator	16	material handler
Maintenance man	66	machine operator
Technical occupations	95	maintenance man
Material handler	85	machine operator
Other occupations (including service workers)	72	semiskilled, n.e.c.

given to workers transferred (job shifts not involving substantial change in job duties) to acquaint them with their new work. 1/ It also excludes "self-training" by which workers acquire or perfect their skills from the study of manufacturers' manuals, by trial and error methods, and by other self-learning processes.

The 68-percent figure may be an understatement. Some employers probably failed to report short on-job training of the sort that other employers made known to survey interviewers.

When on-job training of less than four days is excluded, the proportion of workers given training becomes 60 percent; and when on-job training of one week or less is excluded, it is 51 percent.

As may be seen in table O, the training ratio, when on-job training of one week or less is excluded, tends to be higher for higher-skill occupations than for lower-level ones.

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1. In addition to training given to workers reassigned to the new equipment, a few plants gave training to displaced workers who were reassigned to some part of the plant other than on the new equipment. Nine of 116 establishments reporting such reassignments reported that they gave training in these cases.

Table O. PERCENT OF NEW AND REASSIGNED WORKERS GIVEN TRAINING OF MORE THAN ONE WEEK, BY OCCUPATION

Occupation on new equipment	Number of workers in occupation	Workers given training: Number	Workers given training: Percent of total
All occupations	3,145	1,590	51
Assembler	102	41	40
Craftsman	280	181	65
All-round machinist	5	5	100
Welder	41	16	39
Toolmaker	47	8	17
Baker	42	36	86
Printing craftsman	103	103	100
Machine set-up man	26	13	50
Other craftsman	16	-	-
Clerical occupations	244	227	93
Inspectors and testers	33	10	30
Machine and equipment attendants	789	293	37
N/C machine tool attendant	256	72	28
Conveyor attendant	73	20	27
Packaging machine attendant	95	38	40
Palletizer attendant	60	-	-
Other attendants	305	163	53
Machine and equipment monitors	94	71	76
Remote control monitor	85	62	73
Other monitors	9	9	100
Machine operator	468	175	37
Metalworking machine operator	194	55	28
Finishing, polishing, and sanding machines	39	16	41
Extrusion, molding, and casting machines	69	7	10
Other metalworking machine operators	86	32	37
Other machine operators	274	120	44
Vehicle operator	98	40	41
Maintenance man	317	181	57
Electrical-electronic	43	21	49
Electro-mechanical	30	28	93
Mechanical	84	39	46
Other maintenance men	160	93	58
Technical occupations	368	297	81
N/C programmer	74	47	64
Troubleshooting technician	139	138	99
Other technical occupations	155	112	72
Semi-skilled operatives, n.e.c.	14	-	-
Material handler	284	46	16
Other occupations (incl. service workers)	54	28	52

Table P. TYPES OF TRAINING GIVEN NEW AND REASSIGNED WORKERS, BY OCCUPATION

Occupation	Number of workers given training	Percent distribution by type of training				
		Total	On-job only	Formal class-room only	Both types	Type not re-ported
All occupations	2,135	100	65	5	27	3
Assembler	42	100	5	-	-	95
Craftsman	237	100	52	5	40	3
All-round machinist	5	100	100	-	-	-
Welder	22	100	73	-	-	27
Toolmaker	46	100	96	4	-	-
Baker	42	100	100	-	-	-
Printing craftsman	103	100	-	8	92	-
Machine set-up man	19	100	89	11	-	-
Clerical occupations	231	100	4	1	95	-
Inspectors and testers	10	100	100	-	-	-
Machine and equipment attendants	530	100	92	2	4	2
N/C machine tool attendant	139	100	90	1	-	9
Conveyor attendant	47	100	100	-	-	-
Packaging machine attendant	62	100	100	-	-	-
Palletizer attendant	38	100	100	-	-	-
Other attendants	244	100	87	3	9	1
Machine and equipment monitors	74	100	64	-	35	1
Remote control monitor	65	100	58	-	40	2
Other monitors	9	100	100	-	-	-
Machine operator	300	100	92	7	1	-
Metalworking machine operator	130	100	96	2	2	-
Finishing, polishing, and sanding machines	35	100	100	-	-	-
Extrusion, molding, and casting machines	37	100	100	-	-	-
Other metalworking machine operators	58	100	92	3	5	-
Other machine operators	170	100	89	11	-	-
Vehicle operator	56	100	100	-	-	-
Maintenance man	194	100	76	12	10	2
Electrical-electronic	30	100	53	40	7	-
Electro-mechanical	28	100	82	14	4	-
Mechanical	43	100	91	7	2	-
Other maintenance men	93	100	77	4	16	3
Technical occupations	311	100	26	8	65	1
N/C programmer	53	100	15	36	43	6
Troubleshooting technician	139	100	13	2	84	1
Other technical occupations	119	100	47	3	50	-
Semiskilled operatives, n.e.c.	6	100	100	-	-	-
Material handler	115	100	99	-	-	1
Other occupations (incl. service workers)	29	100	56	41	3	-

The following figures show that the percent of the workers who were given any training (68 percent over-all) was greater for those employed by large establishments:

4- 99 workers	50
100-999 workers	63
1000 or more workers	75

As between sub-groups within these broad size groupings, this relationship of establishment size and proportion of workers trained is not consistent. (Note that this analysis applies to all training regardless of length of training.)

Types of training given. Training for jobs on the new equipment took the form primarily of on-job rather than classroom instruction. This is seen in the following percent distribution of workers trained:

All workers trained	100
On-job training only	65
Classroom training only	5
Both types of training	27
Training status unknown	3

Table P shows this information for the various occupations. The data indicate that training involving classroom instruction (alone or combined with on-job instruction) was concentrated among high-skill occupations, although not all the high-skill occupations emphasized classroom instruction. Classroom instruction figured prominently in training programs in the following occupations; the figure is the percent of the workers trained who received classroom instruction (alone or combined with on-job instruction):

Printing craftsman (mainly photo composition)	100%
Clerical occupations (mainly teletypists)	96
Troubleshooting technician	86
N/C programmer	79
"Other technical occupations"	53
Electrical-electronic maintenance man	47
"Other occupations" (mainly engineers and supervisors)	45
Remote control monitor	40

Most of the training given to new and reassigned workers working on new equipment was done by the companies that employed the workers, but in a number of instances it was given by the manufacturer of the new equipment. The figures at the top of the next page divide the total number trained by who did the training.

Agency	Number	Percent
Total	2,135	100
Company only	1,540	72
Equipment manufacturers only	505	23.5
At company plant	340	16
At manufacturer's plant or school	153	7
At both	12	0.5
Both company and manufacturer	78	4
Training agency not reported	12	0.5

The equipment manufacturer played a particularly prominent role in the training of workers in the following technical and specialized occupations. The figure is the percent trained entirely or in part by the manufacturer:

N/C programmer	89%
Toolmaker	83
Remote control monitor	80
Maintenance man	70
Machine set-up man	68
N/C machine tool attendant	46

The bulk of classroom training was done in the plant of the employer or equipment manufacturer. Very little use was made of the public schools in this connection. Correspondence courses figured prominently in training of workers in one case. (Appendix table III-3.)

Purpose of training. According to the reports of the employers covered by the survey, training was rarely given to a beginning worker. Most training given to new and reassigned workers was to supplement their existing skills:

All workers trained	100%
Train beginning workers	1
Supplement existing skills	76
Retrain for new skills	14
Purpose not reported	9

In the case of a few occupations -- especially machine and equipment attendants and monitors and operators of fork-lift trucks -- retraining for new skills was reported as a primary purpose of training. (Appendix table III-4.)

Duration of training. Most of the training and retraining given to prepare new and reassigned workers for jobs on the new equipment was of relatively short duration: 50 percent of the trainees were trained for one month or less, 47 percent for over one month (duration of training not being reported in cases involving 3 percent of the workers). About one-third were trained

Table Q. DURATION OF TRAINING GIVEN NEW AND REASSIGNED WORKERS, BY OCCUPATION

Occupation	Number of workers given training	Percent distribution by duration of training			
		Total	One month or less	Over one month	Not re-ported
All trainees	2,135	100	49.6	47.2	3.2
Assembler	42	100	4.8	-	95.2
Craftsman	237	100	42.6	54.9	2.5
All-round machinist	5	100	100.0	-	-
Welder	22	100	40.9	31.8	27.3
Toolmaker	46	100	95.7	4.3	-
Baker	42	100	71.4	28.6	-
Printing craftsman	103	100	-	100.0	-
Machine set-up man	19	100	68.4	31.6	-
Clerical occupations	231	100	4.8	95.2	-
Inspectors and testers	10	100	80.0	20.0	-
Machine and equipment attendants	530	100	75.4	22.1	2.5
N/C machine tool attendant	139	100	84.2	7.2	8.6
Conveyor attendant	47	100	100.0	-	-
Packaging machine attendant	62	100	64.5	35.5	-
Palletizer attendant	38	100	100.0	-	-
Other attendants	244	100	64.8	34.8	0.4
Machine and equipment monitors	74	100	10.8	87.8	1.4
Remote control monitor	65	100	12.3	86.2	1.5
Other monitors	9	100	-	100.0	-
Machine operator	300	100	79.0	21.0	-
Metalworking machine operator	130	100	72.3	27.7	-
Finishing, polishing, and sanding machines	35	100	62.9	37.1	-
Extrusion, molding, and casting machines	37	100	91.9	8.1	-
Other metalworking machine operators	58	100	65.5	34.5	-
Other machine operators	170	100	84.1	15.9	-
Vehicle operator	56	100	92.9	7.1	-
Maintenance man	194	100	36.6	61.9	1.5
Electrical-electronic	30	100	83.3	16.7	-
Electro-mechanical	28	100	78.6	21.4	-
Mechanical	43	100	18.6	81.4	-
Other maintenance men	93	100	17.2	79.6	3.2
Technical occupations	311	100	14.8	83.9	1.3
N/C programmer	53	100	62.2	32.1	5.7
Troubleshooting technician	139	100	2.9	96.4	0.7
Other technical occupations	119	100	7.6	92.4	-
Semiskilled operatives, n.e.c.	6	100	100.0	-	-
Material handler	115	100	93.0	6.1	0.9
Other occupations (incl. service workers)	29	100	37.9	62.1	-

for over three months. These figures include on-job, classroom, and a combination of the two forms of instruction.

There were five occupations in which more than half the workers received over a month of training. The figure shows the percent of the trainees who received that much:

Printing crafts (mainly photo composition)	100%
Clerical occupations (teletype operators)	95
Machine and equipment monitors	88
Technical occupations	84
Maintenance men	62

Table Q gives further detail on duration of training.

Special note may be made of the N/C programmers, 62 percent of whom, according to employer reports, received less than one month's instruction. The majority of these were persons hired because they had programming skills or were methods men, industrial engineering technicians, or tool designers who carried over from their old work much of the knowledge required in N/C programming work. Typically, persons with such background required only a few days of instruction by the manufacturer of the N/C equipment.

For maintenance occupations, as well as for N/C programmers, the amount of training time depended on the kinds of skill the new or reassigned worker possessed.

Chapter IV

SKILL LEVEL CHANGES

Shifts in skills and skill requirements that result from changes in technology may be analyzed from several points of view. Only certain of these analyses are used here, because the present survey focused only on what happened within establishments as the result of the changes that took place.

(1) One analysis is concerned with what happens to the skill level of jobs of workers displaced as a result of new technology. The present analysis shows how workers transferred and reassigned fared, so far as the level of their jobs is concerned, but it does not cover those separated (who took jobs with different employers).

A related analysis, which is not set forth in this report, is concerned with those workers employed in connection with the new equipment -- how skills required on such equipment compare with skills in jobs held previously. With some exceptions, these two analyses cover the same group of workers and involve the same comparison of skills when persons separated and new hires are excluded.

(2) A second kind of analysis, also covered in the present survey, is concerned with changes in skills required to perform particular functions -- for example, how skills required to operate or to maintain the new equipment compare in skill level with similar functions on the old equipment. This analysis focuses directly on how particular kinds of technology change the nature and level of skill requirements and permits comparisons of different equipment in this respect.

(3) A third analysis compares the occupational distribution of workers in the plant before and after the technological change. This measures the combined effect of changes in skills required to perform worker functions and of job displacement. It may give different results from those obtained under the function analysis (2, above). For example, a new piece of equipment may involve no change in skill levels needed to perform any of the particular functions involved but rather require fewer workers in some of the occupations affected. The result may be to reduce, say, the proportion of laborers and machine operators, and, as a result, increase the proportion that craftsmen and technicians are of the total. This kind of analysis was not made in any comprehensive way in the present study.

(4) Finally, the analysis may be concerned with the entire labor force, taking into consideration the jobs that workers separated from one establishment find with a new employer and taking into consideration also the extent to which unemployment results from displacement. This kind of analysis, which must deal with the totality of the economy's manpower, takes into consideration changes in the level of the economy and the structure and location of its industry, as well as displacement and job-function shifts resulting from tech-

nological change. The present analysis was intended to contribute information to parts of this over-all analysis but obviously is far more limited in scope. 1/

This fourth, more comprehensive, approach to the problem of changing skill requirements takes in the needs of the economy for design and development of new technology, as well as for its operation and maintenance. Design and development is the function of scientists, engineers, and technicians. It is a function that is fast growing in importance, particularly with developments in the sciences and the applications of electronics.

The use of technicians to assist engineers and scientists in design and development work and projections of requirements for this kind of work were among the subjects of a survey by the New York State Department of Labor, published in 1965. 2/ This study found that in 1962 about 5,000 technicians were engaged in designing and developing control devices and apparatus used in automatic equipment and related kinds of testing and measuring instruments, and that, as the pace of automation technology quickens, some increase in the ratio of technicians to engineers in this work may be expected.

Skill Level Changes

No widespread change in the skill level of jobs accompanied the reassignment and transfer of persons from old to new equipment in the cases covered by the present survey. Two-thirds of the workers shifted did not experience a change. A somewhat higher proportion had an increase than had a decline.

Change in skill level	Number	Percent
All workers shifted	2,936	100
To lower skill level	318	11
To higher skill level	610	21
No change in skill level	2,001	68
Reassigned	1,048	36
Transferred	953	32
Not reported	7	-

Of the total of 5,495 workers on old equipment, these data omit 1,455 who were reassigned or transferred to jobs in the establishment elsewhere than on the new equipment. They omit also the 1,104 displaced workers who were separated from the employ of the establishment as a result of the installation of the new equipment.

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1. See New York State Department of Labor, Division of Research and Statistics, Manpower Directions in New York State, 1965-1975 (1968, two volumes) for an over-all view of New York State's manpower requirements.
2. New York State Department of Labor, Division of Research and Statistics, Technical Manpower in New York State (1965, four volumes).

The decision concerning what if any skill level change was involved in a particular reassignment was a matter jointly determined by the employer and staff employed on the survey. The employer was asked whether a substantial change in the skill level was involved in the reassignment of a worker from his job on the old equipment to his job on the new. His judgment was accepted unless in the judgment of staff assigned to the case it was clearly at odds with the facts.

Persons classified as transferred were ones who did not undergo any change in skill level. In transfers there was by definition no substantial change in job content. Usually a transfer involved nothing more than an organizational shifting of jobs.

The general assumption was made that a reassignment from one of the following grade levels to another involved a skill level change, unless there was evidence to the contrary, such as lack of training time or absence of change in knowledge requirements.

I: Laborer, manual materials handler, manual service worker, elevator operator, routine clerical worker, person doing simple assembly work, etc.

II: Machine operator, product or equipment inspector or tester, machine attendant, machine monitor, person doing complex assembly work, elevator starter, nonroutine clerical work (e.g., typing), etc.

III: Set-up man, maintenance man, craftsman, layout work.

IV: Draftsman, trouble-shooter on complex equipment, programmer, other technician.

V: Engineer, scientist, supervisory personnel.

An upward skill change within one of these grades was recognized in some instances where the shift required substantial training time (such as 2 weeks in grades I-II and 4 weeks in grades III-IV); or if it was clear that substantially more advanced knowledge of engineering, mathematics, science, or technology was required in the new job (e.g., a maintenance man who now had to have substantially more knowledge of electronics, hydraulics, or pneumatics). Similarly, downward skill level changes within grades could be recognized if it was clear that there were substantial differences between the two jobs in training time, knowledge requirements, manipulative ability or other skills.

Generally speaking, doubtful cases were resolved as no-change cases.

As ways mentioned earlier, in over two-thirds of the reassignments and transfers there was no change in skill level. There were about twice as many changes to higher skill levels as to lower ones. Table T brings out the fact that the different occupation groups varied in this respect. Maintenance personnel, technical workers, clerical workers, and machine attendants add monitors are prominent among those showing shifts to jobs at a higher skill level. Inspectors and testers and miscellaneous semiskilled workers -- relatively small groups -- are among those showing shifts to lower ones.

Table R. SKILL LEVEL CHANGES BY OCCUPATION GROUP ON OLD AND ON NEW EQUIPMENT

Previous occupation group	Present occupation group	Number of workers reassigned or transferred	Percent distribution by skill-level change			
			Total	Lower	Same	Higher
Total		2,929	100	11	68	21
Assembler group		226	100	20	59	21
Assembler	Assembler	140	100	-	71	29
Assembler	Machine and equipment attendant	40	100	47	50	3
Assembler	Machine operator	37	100	72	14	14
Assembler	Other occupations	9	100	-	89	11
Craftsman group		325	100	15	69	16
Craftsman	Craftsman	250	100	3	77	20
Craftsman	Machine operator	40	100	88	12	-
Craftsman	Other occupations	35	100	17	83	-
Clerical group		68	100	-	78	22
Clerical	Clerical	53	100	-	100	-
Clerical	Other occupations	15	100	-	-	100
Inspector and tester group		12	100	67	33	-
Inspector and tester	Inspector and tester	12	100	67	33	-
Machine and equipment attendant		208	100	2	61	37
Attendant	Attendant	190	100	3	64	33
Attendant	Monitor	15	100	-	20	80
Attendant	Other occupations	3	100	-	-	100
Machine and equipment monitor		11	100	-	-	100
Monitor	Monitor	11	100	-	-	100
Machine operator		628	100	27	50	23
Machine operator	Machine operator	400	100	11	64	25
Metalworking machine operator	Metalworking machine operator	104	100	26	62	12
Other machine operator	Other machine operator	296	100	6	65	29
Machine operator	N/C machine tool attendant	121	100	57	36	7
Machine operator	Machine and equipment attendant	68	100	73	21	6
Machine operator	Other occupations	39	100	15	82	3
Vehicle operator group		49	100	4	88	8
Vehicle operator	Vehicle operator	40	100	-	100	-
Vehicle operator	Other occupations	9	100	22	33	45
Maintenance man		361	100	(a)	79	21
Maintenance man	Maintenance man	329	100	(a)	82	18
Maintenance man	Other occupations	32	100	-	41	59
Technical occupations		171	100	1	79	20
Technical occupation	Technical occupation	170	100	1	80	19
Technical occupation	Other occupations	1	100	-	-	100
Semiskilled worker group		58	100	41	59	-
Semiskilled worker	Semiskilled worker	26	100	12	88	-
Semiskilled worker	Machine operator	17	100	71	29	-
Semiskilled worker	Other occupations	15	100	60	40	-
Material handler		763	100	2	82	16
Material handler	Material handler	449	100	1	95	4
Material handler	Machine and equipment attendant	212	100	3	75	22
Material handler	Machine operator	27	100	4	63	33
Material handler	Vehicle operator	46	100	-	9	91
Material handler	Other occupations	29	100	-	69	31
Occupations not elsewhere classified		49	100	-	51	49
Occupations, n.e.c.	Occupations, n.e.c.	46	100	-	48	52
Occupations, n.e.c.	Other occupations	3	100	-	100	-

a. Less than 0.5 of a percent.

About 30 percent of the workers who were transferred or reassigned from the old equipment to the new changed their occupation group. Most of these went to a higher or lower skilled job. Largely because of the downgrading of machine operators and assemblers to machine attendant jobs, workers who shifted from one occupation group to another showed a small net decline in skill.

Approximately three-fourths of the workers whose occupation groups did not change were assigned to jobs at the same skill level as their previous jobs. (Appendix table IV-1.)

The pattern of skill level changes experienced by persons who were reassigned or transferred as a result of technological change was determined in part by the number and sort of job opportunities that were available on the new equipment and in part by considerations affecting managements' decisions as to which workers should get which jobs. In part this pattern also reflects the level of skill required to perform the functions of new jobs in comparison with the level required to perform similar functions in the old jobs.

Determination of the skill-level change of workers by analysis of their functions is the subject of the remainder of this chapter.

Analyzing Changes in Skill Levels of Worker Functions

Determining the impact of a new type of equipment on the skill-level required of workers requires, among other steps, that in each situation -

(1) each occupation employed on or in connection with such equipment be broken down into the various functions that workers perform.

(2) similarly, functions on the old equipment that were replaced or modified by the new equipment be identified.

(3) the skill requirements of comparable old and new functions be evaluated in terms of level; also that the skill level of new functions be compared with that of any old functions which they displaced.

(4) functions performed on the old but not on the new, and on the new but not on the old, be identified.

Such an analysis makes it possible to indicate how a particular function (for example, maintenance) on new equipment compares in terms of skill requirements with the same function on the replaced equipment; and, similarly, to compare skill level changes in situations where because of mechanization, one function replaces another (for example, machine operation replaces manual material handling). Then it is possible to say whether the configuration of functions in a particular occupation -- say, machine attendant -- are at a higher or lower level than the same configuration of functions performed in connection with old equipment, in whatever occupations these functions were previously performed and whether in one or several occupations.

Functions defined. The functions used in the present analysis are adaptations of those set forth in the current *Dictionary of Occupational Titles*. [1] The functions are grouped into several classes, first according to the nature of the worker's relationship to materials and equipment ("things functions") and then according to his relation to data ("data functions"):

A. THINGS

Manual Materials Handling

- Moving or carrying objects and materials
- Feeding and loading machines
- Unloading machines; disposing of rejects
- Moving products and materials from one machine to another
- Removing rejects
- Hand packaging

Assembly

- Putting together products and product parts by hand, hand tools, or simple hand-controlled power tools.

Machine Operation

(turning, grinding, milling, drilling, stamping, forging, spinning, bending, packaging, typewriters, and other office machines, etc.) Includes precision working.

- Starting and stopping machines
- Positioning workpiece in machine
- Turning machine off and on and/or operating levers, valves, switches, etc., to advance process from one stage to another or to correct malfunctions
- Guiding action of machine to fabricate and process
- Sensing and observing process for obvious malfunctioning and errors
- Identifying and removing more or less obvious rejects

Inspection and Testing

- Measuring dimensions, temperatures, pressures, and other characteristics of materials in process by use of gauges, micrometers, etc. May involve comparison of measurements with predetermined standards.
- Testing products for performance, chemical analysis, etc.
- May involve recording data on characteristics of production process.

Equipment Tending and Monitoring

- Visual observation and other direct sensing of production process for errors, defects, and malfunctions
- Visual observation of signals and measurements recorded on panel for errors and malfunctioning in production process
- Visual observation of signals and measurements recorded on panel for product dimensions, stage of process, condition of materials in process, etc.
- Recording data on characteristics or keeping a log of production process

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[1] U. S. Department of Labor, *Dictionary of Occupational Titles* (third edition, 1965), volume II, appendix A, pp. 649-650. DOT "people functions" were not utilized because they did not figure prominently in the cases surveyed.

- Compiling, computing, comparing, or analyzing data to determine conformance with standards
- By remote control, turning machines off and on and operating controls to correct malfunctions or to advance process

Driving-Controlling of Vehicles

- Guiding action of machines to move people and things

Troubleshooting and Maintenance

(Fields: mechanical; hydraulic; pneumatic; electrical; electronic; electro-mechanical; combinations of)

- Lubrication and/or cleaning
- Minor corrective adjustments of machine
- Preventive maintenance
- Troubleshooting
- Repairs

Setting Up

- Readying machine or equipment by replacing or altering tools, jigs, fixtures, attachments, etc., to prepare them to perform their functions, change their performance, or restore proper functioning if they break down.

B. DATA

Comparing

- Judge readily observable functional, structural, or compositional characteristics, to select, sort, arrange, signal, discard, etc.

Copying

- Transcribe, enter, or post data.

Computing

- Perform arithmetic operations and report and/or carry out a prescribed action in relation to them.

Compiling

- Gather, collate, classify information; compare data with specifications or standards.

Analyzing

- Examine and evaluate data within frame of reference of a particular discipline, art, technique, or craft, in order to determine alternatives, next steps, consequences, corrections.

Coordination

- On the basis of analyses deciding whether performance and/or problems call for new goals, changes in policies, or revised procedures and technologies.

Synthesizing

- Take off in new directions on basis of intuition, feelings, and ideas; conceive of new approaches; discover new facts and relationship, invent new devices; create original art; reinterpret existing ideas and concepts.

Table T. SKILL LEVEL CHANGE BY FUNCTION

Function	Number of worker functions	Average rating	Number of worker functions with skill level that is-		
			lower	same	higher
All functions	2,300	1.95	429	1,567	304
Troubleshooting and maintenance	203	2.26	2	147	54
Set-up	225	1.98	50	130	45
Machine operation	378	1.82	109	229	40
Tending	566	1.66	230	296	40
Motor vehicle operation	91	2.60	-	36	55
Inspecting and testing	65	1.97	5	57	3
Assembly	130	2.32	-	89	41
Material handling	544	1.98	33	491	20
Data functions	98	2.06	-	92	6

in skill level, 1 for a lower level, and 3 for a higher level of skill on the new in comparison with the old equipment. This average is arrived at by weighting each skill level rating by the number of workers on the new equipment engaged in the function being rated.

When the number of different functions in the cases studied are multiplied by the number of workers involved in each, the total is 2,300 worker functions. Of these, 429 had a downward skill level change and 304 an upward one, while 1,567 had no change. (Appendix table IV-2.)

The data for the different functions are summarized in table T, and the next sections give a description of findings in the case of each.

Note that all but one of the functions listed in table T are those classified as "things functions". The average rating entered for each of the "things functions" is actually the rating for a set of functions that includes a "data function" associated with the particular "things function." For example, the maintenance ("things") function was often associated with the analysis ("data") function; where this is true, the rating for "maintenance" reflects the rating of the "analysis function" as well as the "things function" associated with maintenance.

There are 98 worker-functions that are classified as "data functions" simply (last line of table T), since in some occupations, exemplified by N/C programmer, there were no significant "things functions."

Troubleshooting and Maintenance

The function of troubleshooting and maintenance includes a range of activity designed to maintain machines in working order or restore them when they break down.

A function that was present in the new equipment but not in the old was rated 3 -- as an increase in skill level. One present in the old but not in the new was rated 1 -- as a decrease in skill level, again using the number of workers performing the function as weights.

The sum of the function ratings was divided by the total number of functions performed to obtain an average rating.

A related measure used in the analysis is the number of worker-functions in which there was an increase in skill level, a decrease, or no change. All workers performing the machine operation function, for example, were rated 1, 2, or 3. Any worker would be counted as often as the number of different functions he performed.

These obviously are rough ways of gauging skill-level change. They give each worker-function combination (things plus data) the same weight as every other one, regardless of the critical importance of or amount of work time spent in performing each of the various functions. They do not distinguish between degrees of change, giving as much weight to a small change as a large one.

Moreover, there were inevitably some differences among the analysts engaged in the study in the matter of what functions were deemed significant enough to be recorded and what constituted a real change, up or down.

One further consequence of the complicated nature of this function analysis was the inability to obtain relevant data from a substantial segment of the employers otherwise represented in the survey. It is available here for 160 or 60 percent of the 266 cases that were taken up in chapter II. The function analysis covered 1,616 workers, who performed 2,300 sets of functions on new equipment -- 49 percent of all workers in the survey.

Table S shows that the coverage ratios vary a good bit among the various types of equipment. (The exceptionally low worker coverage ratio in the feedback instrumentation category is explained by the failure of a large electrical utility to report on this subject.)

The following pages present the results of the analysis of skill level change by worker function. They are given, despite the limitations of the procedures and the study sample, because they illustrate various impacts of technological change on skill levels and because they may suggest generalizations and qualifications that should accompany generalizations on the subject.

Skill Level Changes in Worker Functions

In the sample of cases studied, the analysis found no pronounced tendency in the direction of either upward or downward changes in skill level of worker functions.

The total weighted - average rating for all cases studied was 1.95 on a scale which, as previously explained, gives a weight of 2 for no change

Table S. NUMBER OF CASES AND WORKERS COVERED IN THE FUNCTION SKILL LEVEL ANALYSIS, COMPARED WITH TOTAL IN THE SURVEY

Type of new equipment	Number of cases and workers in the survey			Cases and workers (number and percent of total) covered in function analysis					
				Cases		Present workers		Previous workers	
	Cases	Present workers	Previous workers	Number	Percent	Number	Percent	Number	Percent
All types	266	3,330	5,495	160	60	1,616	49	2,703	49
Automatic production lines	12	395	569	8	67	279	71	372	65
Process production	5	302	428	4	80	220	73	278	65
Automatic transfer lines and machines	7	93	141	4	57	59	63	94	67
Instrumentation additions	38	781	1,157	24	63	195	25	488	62
Feedback control	9	438	508	4	44	17	4	27	5
Other	29	343	649	20	69	178	52	461	71
Metalworking machinery and related equipment	97	814	1,150	55	57	417	51	528	46
N/C machine tools	40	426	493	28	70	233	55	233	47
Electric discharge machines	6	16	12	6	100	16	100	12	100
Other metal cutting machines	17	65	125	-	-	-	-	-	-
Riveting, welding, and soldering machines	10	145	218	7	70	129	89	142	65
Finishing, polishing, and sanding machines	11	49	123	5	45	9	18	57	46
Forming and casting machines and equipment	13	113	179	9	69	30	27	84	47
Mechanical material handling and moving equipment	34	473	972	28	82	332	70	714	73
Conveyors	19	299	435	15	79	163	55	292	67
Fork-lift trucks, palletizing and other equipment	15	174	537	13	87	169	97	422	79
Packaging and related equipment	20	211	393	12	60	114	54	184	47
Assembly and related equipment	20	188	441	12	60	101	54	175	40
Other equipment	45	468	813	18	40	161	34	242	30

The Dictionary of Occupational Titles also recognizes a "people function." This dimension has been disregarded in the present analysis because there was not sufficient information to rate it, in most cases.

Judging skill level changes. As to a given job, whether the skill level of particular functions increased, decreased, or remained the same was judged by looking at factors 1/ that included the following:

(1) Manipulative skill. Eye and hand or finger and/or foot coordination; finger or hand dexterity.

(2) Responsibility. The financial consequences and worker injuries that might result from an error in judgment or action.

(3) Subject-field knowledge. The mathematical, scientific, and technological areas of knowledge needed to perform the job.

(4) Technical skill. The ability to use reference materials, such as blueprints and schematics and technical manuals and handbooks, and such equipment as hand and power tools, drafting instruments and equipment, mechanical precision measuring instruments, slide rules and desk calculators, electrical and electronic instruments and equipment, colorimeters, microscopes, hardness testers, X-ray machines, etc.

(5) Knowledge of process or product. The extent to which a knowledge of the product or process was needed in the performance of the job, and whether the depth of knowledge required was directly or inversely related to the amount of instrumentation involved in the process.

(6) Work with data. As previously mentioned, the relationship of the work done to analytical and other data functions was considered.

The analyst visiting the plant was asked to discuss with the employer the question of what if any changes took place in the various factors and, based on this discussion and his own analysis of the change in functions, to reach a conclusion as to the skill level change in each function in each case.

Rating and weighting functions. The skill level change of each function performed in connection with the new equipment in comparison with the old was rated:

1 - if it was downward (lower on the new equipment)
2 - if it was the same
3 - if it was upward (higher on the new equipment)

---

1. Trivial changes were disregarded. Unless the change was regarded as substantial, the case was characterized as "no change."

Identifying the source of difficulty and repairing are typically done by maintenance mechanics, as is also preventive maintenance work. Identifying sources of malfunction on complex equipment, especially advanced electronic and electro-mechanical equipment, may require the services of a technician, commonly called a "troubleshooting technician."

The cases under study show an upward tendency in the average skill level required to perform the maintenance function. Virtually all the changes in skill level recorded were upward. However, in the largest proportion of cases there was no change in skill level.

- Over-all rating of function 2.26

- Number of workers performing the troubleshooting and maintenance function on new equipment for whom there was -

no change in skill level	147
upward change	54
downward change	2
total	203

Of the total of 203 worker functions there were 23 in which there had been no maintenance function in the operation that was replaced. These typically were cases in which manual operation was replaced by machinery for material handling, packaging, and assembling and other types of mechanical equipment. These 23 were all classified as having upward changes in skill level.

Most of the remaining cases in which an upward skill level change was recorded were ones in which instrumented machines replaced machines without instrumentation, or in which machines highly sophisticated in terms of measuring and reacting capabilities replaced machines with less sophisticated instrumentation.

The relative importance of the no-change cases may be overstated:

(1) While maintenance of numerically controlled machine tools usually was reported as involving no change in skill level, in these cases major troubleshooting and repair problems were almost always referred to the manufacturer of the equipment.

(2) In large plants difficult troubleshooting problems may be referred to engineering or technician staff not specifically assigned to the particular equipment installations surveyed and hence in some instances not recorded in the survey.

Perhaps the most significant impact of advanced industrial technology on the equipment maintenance function has been the growth in need for troubleshooting engineering technicians in the electronics and electro-mechanical fields, tasks that typically require advanced study beyond high school, or equivalent experience and on-job training. A large proportion of these technicians are employed by the manufacturers of the equipment to service customers. This group of engineering technicians totaled 20,000 in 1962. A 1964 publication of the New York State Department of Labor describes in detail their work and the education and experience required for it. [1]

(3) Another reason for believing that no-change cases are overemphasized in the data of the present survey is that a number of the no-change cases involved minor corrective maintenance functions performed by machine operators and attendants, rather than substantial troubleshooting and maintenance tasks of the sort ordinarily handled by maintenance mechanics or troubleshooting technicians.

Set-up

The set-up function is mainly concerned with installing and changing tools and dies, and other fixtures, and also in other ways preparing the machines for operation and changing their performance.

Setting-up is commonly performed by craftsmen who specialize in and devote a large part of their time to it. It is also performed by all-round machinists, tool makers, and not infrequently by machine operators.

In the cases studied, about two-thirds of the set-up work was found on machine tools. Other set-up work was found in connection with automatic production equipment, instrumentation devices, packaging, and other types of production equipment.

On the average there was little change in the skill level of set-up work on new as compared with the old equipment.

. Over-all rating of function	1.98
. Number of workers performing the set-up function on new equipment for whom there was -	
no change in skill level	130
upward change	45
downward change	50
total	225

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[1] New York State Department of Labor, Division of Research and Statistics, Technical Manpower in New York State, especially volume II, chapters III and IX.

Downward changes in skill level tended to concentrate in cases involving numerically controlled machine tools. The reason for a downward change in these cases is that much of the decision making as to speed and feed was taken over by the methods man or programmer (see section on data functions, below); also, N/C typically did not utilize complicated jigs and fixtures.

Metalworking machines other than N/C typically required either no change or an increase in the skill-level requirements of set-up work. In the case of equipment other than metalworking the tendency also was to have no change in skill level or an upward change. The data do not point to any underlying explanation of the difference between these no-change and upward-change cases. For example, in some cases instrumentation eliminated or reduced set-up functions (e.g., setting of rollers in a rubber extrusion process replaced by Beta-guage adjustment) but in other cases it made set-up a more critical part of the production process because of the complicated and critical adjustments required (e.g., setting up and adjusting fast knitting machines that replaced slower types).

Machine Operation

This function differs from the equipment-tending function in that the operator has direct control over the operation of the machine and to a degree over the quality of the product. He typically positions a workpiece in machine; operates levers, valves, switches, etc., to advance the process from one stage to another or to correct malfunctions; guides the action of the machine to fabricate and to process; senses and observes the process for obvious malfunctions and errors; identifies and removes more or less obvious rejects. The function is performed on office machines as well as industrial machines.

Although on the average a small downward change was found in the skill level of machine operation on new equipment in comparison with old, in well over half the cases there was no change.

- Over-all rating of function 1.82
- Number of workers performing the machine operation function for which there was -

no change in skill level	229
downward change	109
upward change	40
total	378

About three-fourths of the cases were ones in which one type of machine replaced another. Most of these were no-change cases, there being no significant change in the knowledge or technical skill requirements or responsibility of the operator.

The remaining no-change cases involved the displacement by a machine of a material-handling function. These were machines that were simple to operate, considered not to require skills beyond those of the manual work replaced. A prominent example is the replacement of hand packaging by a nonautomatic packaging machine which required an active controlling function by the operator.

Three types of situation account for cases in which new equipment resulted in a downward change in the skill level of machine operation.

In one, machines replaced hand assembly and material handling. Examples include mechanization of -

- assembly of printed circuit boards
- soldering processes
- spray painting
- garment cutting
- adjusting electrical relays to required standards of performance

In these cases operation of the new equipment was judged to require less manipulative ability without compensating increases in technical skill or knowledge requirements.

Another type of situation involved new machines (button-sewers, photoprinters, buffers and polishers, teletypewriters, and others) that required less manipulative ability and technical know-how to operate than the machines they replaced.

In the third type of situation, involving workers indirectly connected with the new equipment, the installation of numerically controlled machine tools and electric discharge machines reduced the skills required of toolmakers. Previously they made complicated jigs, fixtures, and dies on conventional machines. The new equipment required relatively simple holding devices or electrodes.

A high proportion of the upward skill changes resulted from the mechanization of material-handling functions. Most were accounted for by the greater manipulative ability required to operate palletizing, depalletizing, stacking, and bulk unloading machines, which took over common laborer types of work. Other cases involved the chemical coating of metals by machine rather than by hand brush, and the mechanization or manual feeding operations for metal forming and stamping machines.

Tending

This function includes the observation of equipment in operation for the purpose of detecting errors or malfunctions in the production process. This may be done by observing the process directly or by observing signals and measurements registered on instruments on the equipment or on panels at other locations. The function also may include observation of signals and measurements to determine product dimensions, stages of process, conditions of materials in process; recording, compiling, comparing and analyzing data to determine conformance with standards; and by remote control turning machines off and on and operating control instruments to correct malfunction or to advance or alter the process.

In the cases studied here, most tending work was found on automatic palletizing equipment, N/C machine tools, automatic production lines, instrumented machines and equipment, and conveyors. Where tending was considered to be an integral part of a machine-operation function, such as on conventional metalworking machines, no tending function was recorded.

The survey found that the tending function, generally speaking, required less skill than the functions it replaced.

. Over-all rating of function	1.66
. Number of workers performing the tending function on new equipment for which there was -	
no change in skill level	296
upward change	40
downward change	230
total	566

The largest group among the cases of increasing skill requirements was that in which tending replaced machine operation. Most of these involved the installation of electronically controlled passenger elevators (in which starters replaced elevator operators). Other cases involved the tending, rather than operation, of hose-clamp assembly machines; and remote control monitoring of pulp-bleaching equipment.

The next largest group of increasing skill requirements was that in which tending replaced manual material handling. These cases included the tending of machines that measured ingredients by automatic scales (e.g., butter, yeast, salt, sugar going into bakery products). Other cases involved automatic packaging of products. Both processes were previously done by hand. Both required understanding of the functioning of the machines and of the dials and signalling lights.

Another group of increasing skill requirements was that in which tending of remote control panel boards replaced the tending of individual machines or pieces of equipment in milk processing and in wood pulp production.

Knowledge of process and financial responsibility were key factors in the determination that the level of skill on remote control panel board operation was higher than the level in functions displaced.

Most downward changes were found in cases in which tending replaced machine or vehicle operation. These included the installation of numerically controlled machine tools; electric discharge machines; automatic transfer devices; instrumented bottling and packaging equipment; metal forming, molding, and welding equipment; and automatic palletizers. Not all shifts from operation to tending in these cases, however, involved a lowering of skill level.

The downward classification of skill level in these cases was based primarily on the lesser requirements of manipulative ability and technical skill of tending than machine operation functions. Knowledge of process was thought to be as important in the tending functions as in the machine operation functions that were replaced. Financial responsibility involved in tending the new equipment was considered generally to be higher than in the operation of equipment replaced.

A shift from manual material moving and packaging to tending of conveyors and other mechanical material moving equipment, such as automatic stackers and palletizers and automatic packaging equipment, accounted for around two-fifths of the no-skill-level change cases. Another prominent group of no-change cases included shifts from tending of old types to tending of new types of equipment (not employing remote control panels).

Vehicle Driving and Controlling

Functions classified under this heading for the most part were those involved in the operation of fork-lift trucks, cranes, and other vehicles for moving materials. Most of these cases were included in the survey because they were incidental to other technological changes such as installation of automatic packaging equipment and palletizers.

Where vehicle driving and controlling replaced manual material moving, as in the case of fork-lift trucks, it was reported as involving a higher level of skill than the former operation. Responsibility for safety of others as well as manipulative ability were the principal factors here.

Where vehicle operation replaced a previous vehicle function, as in the operation of a new kind of crane, it was reported as involving the same skill level.

. Over-all rating of function	2.60

. Number of workers performing the vehicle operation function on new equipment for which there was -

no change in skill level	36
upward change	55
downward change	none
total	91

Inspecting and Testing

This function is primarily that of determining whether materials and products meet predetermined standards as to content or performance. Cases included in the present analysis involved the measurement of dimensions, temperatures, and chemical composition, by the use of gauges, micrometers, and other equipment and by laboratory analysis.

Generally speaking, the visual inspection for obvious defects done by equipment operators and tenders was not recorded here as an inspecting or tending function. Also inspection and testing of incoming materials or final products were excluded in cases in which the technological change under study was limited to the production of parts or limited phases of the production process. Relatively few cases of inspection and testing functions -- in which more or less formalized and deliberate measurement or analysis was carried out as part of a given process -- therefore were reported in the study. It seems probable that there was a difference among the field staff in deciding when inspection and testing should be reported.

In most cases no change in skill level was reported:

. Over-all rating of function	1.97
. Number of workers performing the inspection and testing function on new equipment for which there was -	
no change in skill level	57
downward change	5
upward change	3
total	65

The largest group of workers reported as engaged in inspecting and testing was employed on food and chemical processes. In an automated bakery process, for example, mixers tested dough by tasting and examination both before and after the installation of the new equipment. Similarly in the automation of milk processing a receiving operator tested incoming raw milk, while technicians subjected the finished product to laboratory tests.

Another group included numerically controlled machine tool cases, where the inspection and testing out of the first item in a class of products had critical significance.

As already indicated, technological innovations in the cases studied did not have any impact on the inspection function in most cases, the technical knowledge and other requirements of the function remaining essentially as they had been before.

Hand Assembly

The assembly of products and product parts by hand, with hand tools, or with hand-controlled power tools figured in seven cases in which there was an improvement in the tools or equipment utilized by the assembly operators.

No cases of downward skill-level change were reported; in five there was no change, in two an upward change. The no-change cases involved relatively simple skills that did not change in essential respects.

One of the upward change cases involved 40 workers engaged in assembling dolls. Previously they had a production-line type of assembly in which each operator was limited to a specific operation. The innovation added special equipment for heating the material to facilitate the assembly process and called on each operator to perform the entire assembly operation. Several months of on-job training were reported as required.

As a result of this case the average skill-level change is on the plus side.

. Over-all rating of function 2.32

. Number of workers performing the assembly function for which there was -

no change in skill level	89
upward change	41
downward change	none
total	130

It is likely that a larger sample would have given different results -- with a somewhat lower proportion of upward change cases. As reported elsewhere, the machine operation and tending functions replaced the assembly function in a number of cases.

Manual Material Handling

This function involves the manual movement of objects and materials with or without the aid of dollies, carts, or similar nonmechanized devices. The movement may be from one machine to another; from storage areas to machines or vice versa; from machines to scrap piles or to inspection and repair stations; from machines, conveyors, or stock piles to boxes, cartons, or other types of shipping containers. It includes the feeding and loading of machines where this is not an integral part of another function such as machine operation or assembly. The function also includes hand packaging and manual clean-up and janitorial operations.

In the vast majority of cases surveyed there was no change in the skill level of the material handling function:

. Over-all rating of function	1.98

. Number of workers performing the manual material handling function for which there was -

no change in skill level	491
upward change	20
downward change	33
total	544

In the typical case manual material handling operations continued on with little or no change in the nature of the work performed. Typically these were subsidiary operations which were not affected by the technological change.

Declines in skill level usually were associated with equipment installations that substantially reduced the amount or complexity of machine feeding and loading operations. In one case, involving the installation of an automatic pen assembling machine, manual assembly operations were in effect replaced by a machine whose only labor requirement was a simple feeding task.

Most of the upward changes in skill level were found in a case involving the installation of mechanized tank cleaning equipment in a brewery. The manual functions remaining in the cleaning of the tanks were reported to require more care and a somewhat higher level of skill. In two cases, the new technology required material-handling functions that were not comparable to or related to any functions associated with the old technology. The remaining cases required greater manipulative ability in the feeding of machines.

"Data Functions"

Among functions encountered in the survey were several that in the instances of technological change studied had no connection with any of the "things functions" discussed above. They primarily involved the coordinating and compiling of data.

(The performance of the "things functions" requires that workers either be in direct contact with or in close attendance to machines, equipment, or materials. As previously indicated, most of the "things functions" are associated with a "data function.")

On average there was a small increase in the skill level of "data functions." The few changes reported were all upward:

. Over-all rating of function	2.06

. Number of workers performing the "data functions" on new equipment for which there was -

no change in skill level	92
upward change	6
downward change	none
total	98

Almost half of the worker functions were reported in cases involving numerically controlled machine tools. Most were concerned with programming the machines. "Coordinating" was the "data function" most commonly involved in programming numerically controlled machine tools. It was also the "data function" involved in preparing conventional machines for operation -- a function that had been performed by set-up men, methods men, machinists and other machine-tool craftsmen. Four of the six upward-change cases involved N/C machines, cases in which particularly expensive and highly flexible N/C machines were judged to require additional knowledge and to involve additional responsibility in comparison with those replaced.

Of the other upward skill-level changes, one involved programming an automatic cardboard and paper cutting machine. The other involved a new job in the automatic processing of chemicals.

Prominent among persons who performed "data functions" with no change in skill level, in addition to N/C programmers, were supervisors -- who also had had supervisory responsibilities in connection with the old equipment -- and methods men (in cases involving the introduction of new welding machines).

Level of Mechanization

The foregoing analysis of job functions suggests an absence rather than presence of relationship between skill-level change and level of mechanization.

The question to which this generalization applies is whether skill levels required by functions that workers perform rises as equipment becomes more highly mechanized and automated -- or whether the relationship is an inverse one, with the functions left to be performed by human labor needing less skill than previously. The third possibility -- closer to the findings of the present study -- is that functions vary in respect to the relationship of level of skill and level of mechanization.

An analysis of this sort requires that both the old and the new equipment involved in a technological change be rated according to a scale of mechanization; and that the direction of change in mechanization level, whether up or down, then be compared with the direction of the change in the skill level required by the two sets of equipment.

The analysis has been aided by the classification of mechanization levels developed by James Bright, as set forth with modifications in appendix A of this report. All cases included in the analysis of skill level changes by function were classified according to this grouping.

In practice it was found that there was insufficient information in a number of cases to follow the details of this classification structure with assurance. Therefore, while the analysis seems adequate for some generalizations, it does not permit a detailed analysis of skill-level changes and levels of mechanization.

The present analysis covers functions apt to be directly involved in the cases of technological change studied -- troubleshooting and maintenance, set-up, machine operation, and machine tending and monitoring.

Troubleshooting and maintenance. The cases studied suggest that there is an increase in the skill level of the troubleshooting and maintenance function as the level of mechanization rises -

- where machines that perform a sequence of fixed functions replace single-function machines.
- where machines with capability of reacting to measurement replace machines with no such capability or a limited one.

Set-up. The relationship of skill level and mechanization level in the set-up function varies among different types of equipment:

- The elimination of complicated jigs and fixtures in conversions from conventional to numerically controlled machine tools -- involving in effect the transfer of some set-up operations to programmers -- results in an inverse relationship.
- Similarly, lower skill requirements were apparent in cases involving introduction of feedback instrumentation.
- As to changes in other types of equipment, the only generalization which the cases warrant is that there is apt to be no change in set-up skill level as the level of mechanization rises, with exceptions falling into the upward-change category.

Machine operation. Diverse tendencies prevent generalization concerning skill-level changes and level of mechanization in the case of the machine-operation function:

- The replacement by machines of manual material handling was generally accompanied by an upward change in skill where the manual work was simple and unskilled in nature, as in the replacement of manual material moving by palletizing and stacking equipment. Downward changes, on the other hand, accompanied machine replacement of manual work requiring substantial manipulative ability, as in the case of involved assembly and hand precision work.
- The replacement of hand packaging by machines typically did not affect skill-level requirements.
- The replacement of one type of machine by another was accompanied in some cases by upward and in others by downward changes, but no-change cases were more numerous. Level of mechanization therefore did not appear to be a consistent factor in the machine-to-machine changes studied.

Tending. Diverse tendencies also characterize the relationship of tending function skills and level of mechanization:

- At the highest level, where monitoring a remote control panel replaces direct machine tending or machine operation, there tends to be an increase in skill level, although instances of no change appear.
- At lower levels, where tending replaces machine operation -- a numerically important group of cases -- there is a pronounced downward tendency in skill level (a notable exception being the replacement of elevator operators by starters with the installation of electronically controlled elevators). No change is characteristic where tending replaces tending.
- Where machine tending replaces manual material handling or manual assembly work there are instances both of upward change and no change, with no changes being more numerous among those studied.

Occupation Skill Level Changes

The skill-level rating of an occupation does not necessarily reflect a change in the skill level of the workers in the occupation assigned to the new equipment as compared with the workers in the same occupation who were assigned to the old equipment. Rather it reflects a change in the skill level of functions performed by the workers in the new equipment occupation compared with the functions required by the old equipment regardless of the occupations to which they were assigned.

Typically, however, one function is predominant in any occupation -- the function that helps determine the classification and title of the occupation -- so that the occupational picture resembles the functional picture of skill-level changes.

Two major exceptions involve the machine-operator and craftsman occupation groups. The over-all rating of machine operators is significantly lower than the rating of their machine-operation function because in a number of cases machine-tending functions were assigned to machine operators at lower levels of skill. The rating for craftsmen is largely a composite of the set-up function (higher skill level) and the machine operation function (lower skill level).

Appendix table IV-2 shows the distribution of functions in each group of occupations employed on new equipment and the skill-level change data for each. Table U summarizes the data, giving the aggregate of the skill-level changes for the functions found in each occupation group.

One generalization suggested by the data is that occupations principally concerned with troubleshooting and maintaining the new technology have an upward trend in skill level while those principally concerned with operating the new machines (including craftsmen) have a downward trend.

The high rating of vehicle operators reflects the replacement of unskilled manual material handling by fork lift trucks; conversely, the low rating of machine tenders reflects, to some extent, the replacement of fork lift trucks by conveyors.

Table U. SKILL LEVEL CHANGE, BY OCCUPATION GROUP

Occupation group (a)	Number of worker functions	Number of worker functions for which, in terms of skill level, there was --			Rating
		Downward change	No change	Upward change	
All occupations	2,300	429	1,567	304	1.95
Assembler	113	-	71	42	2.37
Material handler	318	1	297	20	2.06
Machine and equipment attendants	645	184	438	23	1.75
Machine and equipment monitors	65	2	53	10	2.12
Machine operator	355	129	195	31	1.72
Vehicle operator	83	4	24	55	2.61
Inspectors and testers	18	8	10	-	1.56
Other semiskilled operators	44	3	32	9	2.14
Clerical occupations	53	4	48	1	1.94
Craftsman	325	91	192	42	1.85
Maintenance man	164	2	116	46	2.27
Technical occupations	83	1	73	9	2.11
Other occupations	34	-	18	16	2.47

a. See chapter III for descriptions.

The requirement that remote-control panel board monitors have a substantial knowledge of the process which they control, together with heavier responsibilities, tended to raise their skill level group in relation to the machine operators and attendants whom they replaced.

Two groups -- material handlers and clerical workers -- showed little tendency to move either up or down the skill ladder, because for the most part they transferred their functions from the old to the new technology without change. Except for one case, the skill level of assemblers also remained virtually unchanged.

In two of the groups shown -- inspectors and testers and other semiskilled occupations -- the sample of cases available for study of skill level change was especially light. The data shown for them, therefore, probably have limited significance.

Appendix A

LEVELS OF MECHANIZATION

The classification of mechanization levels given here and used in the study is adapted from one developed by James Bright. 1/ His levels of mechanization have been revised and divided into two classes:

A. The first digit of the code numbers differentiates between manual operations, hand controlled power tools, and single and multi-function machines with and without remote control.

B. The second digit describes the types of machine response. Code 0 is always entered after first-digit codes 1 and 2.

A. First Digit Codes

Code

1. Bright's lowest three levels: hand, hand tool, and powered hand tool. It includes such operations as hand packaging, manual materials handling, and the use of such tools as hammers, pliers, wrenches, portable drills, welding guns, etc.

2. Bright's level 4: hand controlled power tools. This group includes machines that have a physical framework to guide and limit tool action. However, the operator must direct the application of the tool to the work piece and control the amount of action, its duration, and its direction relative to the work piece. Examples include drill presses, simple milling machines and lathes, grinding wheels, fork-lift trucks, and electric hoists.

3. Bright's level 5: single-function power tools. At this level the machines perform one action without human intervention. The action may automatically repeat itself. Single-spindle drill presses and other automatic and semiautomatic machine tools, belt conveyors at set speeds, continuous annealing ovens, and many chemical process equipments are at this level.

4. Bright's level 6: sequence of fixed functions. On this level, machines perform a series of different actions in a prescribed sequence without manual assistance. There are two types of mechanization at this level:

   (a) the work piece is held in a given position while different tools are successively brought to bear. This is the principle of the automatic turret lathe.

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1. James R. Bright, Automation and Management, Harvard University Press, 1958, Chapter 4.

(b) each operation is performed at its own station, with the work being automatically passed on to successive stations under automatic timing, positioning, and material handling control. This is the principle of a dial indexing machine or a continuous process. Numerically controlled machine tools and transfer lines and machines combine both of these concepts.

5. First-digit code 5 indicates a code-3 machine with remote control (geographically separated control).

6. Similarly, this code indicates a code-4 machine with remote control.

B. Second Digit Codes

Code

0. This code is used with first digit codes 1 and 2. When used with codes 3 and 5, it indicates that the cycle of the single-function machine is a fixed, repetitive one that can be modified only by a manual operation. Similarly, when used with codes 4 and 6, it indicates that the cycle of each of the functions performed in a prescribed sequence is fixed and repetitive and can be modified only by a manual operation.

1. Bright's level 8: actuation by introduction of the work piece. At this level machines idle or remain inactive until tripped into action by the introduction of the work piece.

2. Bright's levels 9, 10, and 11: measurement of a characteristic, signaling selected valves, and recording performance. This level introduces automatic measurement. The measurement may be that of weight, dimensions, temperature, pressure, etc. The measurement may appear on a dial of an instrument or be printed on a continuous chart. In addition, it may involve a comparison with a standard that actuates a signal and/or shuts down the machine when prescribed limits are reached. At this level, the only machine reaction is automatic shut-down.

3. Bright's levels 12 and 13: changing speed, position, or direction, or segregating or rejecting according to measurement. Measurement at this level causes the machine to choose between a limited number of predetermined, alternative actions, generally of the "go or no-go" type. It is basically an inspection and material-handling response. Using the feed-ahead principle, a signal generated by a measurement causes the machine to follow a predetermined pattern of action. For example, photo-electric controls on a conveyor system may, after counting a specified number of cartons, switch the conveyors to send the next group to a different location. Automatic inspection devices that measure weight or volume may signal the machine to reject substandard items or to segregate the items on the basis of the measurements taken.

4. Bright's level 14: identifying and selecting appropriate action. This level differs from the preceding level principally in the complexity of decision and response. Whereas the lower level is fundamentally a single-action response, level 4 may involve a series of different subsequent actions or a wide range of choices. Instead of inspection and material handling it embraces inspection plus appropriate choice of production action. It is found in a number of chemical processes in which a characteristic in the incoming material is continually measured and the processing operation is continually and appropriately changed.

5. Bright's level 15: correcting performance after operating. At this level self-correction of errors is introduced. It involves automatic inspection and the translation of the inspection information into corrective action within the machine so that the next piece is properly processed.

6. Bright's level 16: correcting performance while operating. Machines at this level, theoretically, would produce no rejects since inspection and machine adjustment take place during the process. Included here would be computer-controlled processes and adaptive control of N/C machine tools.

APPENDIX B

APPENDIX TABLES

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Table I-1. NUMBER OF CASES, BY INDUSTRY AND TYPE OF NEW EQUIPMENT

Type of new equipment	All industries	All manufacturing	Durable goods manufacturing							
			Total	Primary metal	Fabricated metal products (a)	Machinery (b)	Electrical machinery	Transportation equipment	Instruments	Other
All types	281	241	155	16	31	36	27	18	14	13
Automatic production lines:	15	15	10	2	4	-	1	-	1	2
Process production	6	6	2	-	-	-	-	-	-	2
Automatic transfer lines and machines	9	9	8	2	4	-	1	-	1	-
Instrumentation additions:	39	21	5	3	-	1	-	-	-	1
Feedback control	10	7	2	-	-	1	-	-	-	1
Other	29	14	3	3	-	-	-	-	-	-
Metalworking machinery and related equipment:	105	102	101	6	20	32	17	14	12	-
Numerically controlled machine tools	44	42	42	-	1	20	6	8	7	-
Electric discharge machines	8	8	8	-	2	4	1	1	-	-
Other metal cutting machines	18	17	17	-	3	5	4	3	2	-
Riveting and welding machines	11	11	11	-	2	2	3	2	2	-
Finishing, polishing, and sanding machines	11	11	11	2	6	1	2	-	-	-
Forming and casting machines and equipment	13	13	12	4	6	-	1	-	1	-
Mechanical material handling and moving equipment:	35	28	14	1	5	-	5	-	1	2
Conveyors	20	16	12	1	5	-	4	-	1	1
Fork lift trucks, palletizing and other equipment	15	12	2	-	-	-	1	-	-	1
Packaging and related equipment	20	18	4	-	1	-	-	1	-	2
Assembly and related equipment	20	20	7	-	1	1	3	2	-	-
Other equipment	47	37	14	4	-	2	1	1	-	6

Continued

Table I-1 - continued

Type of new equipment	Nondurable goods manufacturing						Nonmanufacturing				
	Total	Food	Chemicals	Paper	Miscellaneous (c)	Other	Total	Service	Trade	Communication	Other
All types	86	31	12	12	11	20	40	12	6	6	16
Automatic production lines:	5	2	2	1	-	-	-	-	-	-	-
Process production	4	2	2	-	-	-	-	-	-	-	-
Automatic transfer lines and machines	1	-	-	1	-	-	-	-	-	-	-
Instrumentation additions:	16	4	3	4	-	5	18	4	1	4	9
Feedback control	5	-	2	1	-	2	3	-	-	1	2
Other	11	4	1	3	-	3	15	4	1	3	7
Metalworking machinery and related equipment:	1	-	-	-	-	1	3	2	-	-	1
Numerically controlled machine tools	-	-	-	-	-	-	2	1	-	-	1
Electric discharge machines	-	-	-	-	-	-	-	-	-	-	-
Other metal cutting machines	-	-	-	-	-	-	1	1	-	-	-
Riveting and welding machines	-	-	-	-	-	-	-	-	-	-	-
Finishing, polishing, and sanding machines	-	-	-	-	-	-	-	-	-	-	-
Forming and casting machines and equipment	1	-	-	-	-	1	-	-	-	-	-
Mechanical material handling and moving equipment:	14	8	3	2	1	-	7	1	2	-	4
Conveyors	4	1	1	2	-	-	4	1	2	-	1
Fork lift trucks, palletizing and other equipment	10	7	2	-	1	-	3	-	-	-	3
Packaging and related equipment	14	8	3	2	-	1	2	-	2	-	-
Assembly and related equipment	13	-	-	1	6	6	-	-	-	-	-
Other equipment	23	9	1	2	4	7	10	5	1	2	2

a. Includes ordnance. b. Machinery, except electrical. c. Miscellaneous manufacturing industries.

Table I-2. NUMBER OF CASES, BY SIZE OF ESTABLISHMENT AND TYPE OF NEW EQUIPMENT

Type of new equipment	All sizes	Size of establishment									Median size
		4 to 19 workers	20 to 49 workers	50 to 99 workers	100 to 199 workers	200 to 499 workers	500 to 999 workers	1,000 to 1,999 workers	2,000 to 4,999 workers	5,000 or more workers	
All types	281	8	16	16	57	70	50	33	21	10	320
Automatic production lines:	15	-	-	-	4	3	2	3	2	1	608
Process production	6	-	-	-	2	2	1	-	1	-	260
Automatic transfer lines and machines	9	-	-	-	2	1	1	3	1	1	1,000
Instrumentation additions:	39	1	1	2	8	8	6	7	4	2	390
Feedback control	10	-	1	2	2	1	1	3	-	-	208
Other	29	1	-	-	6	7	5	4	4	2	600
Metalworking machinery and related equipment:	105	3	8	4	23	21	17	12	12	5	361
Numerically controlled machine tools	44	2	2	1	5	8	7	7	9	3	700
Electric discharge machines	8	-	2	-	2	3	-	1	-	-	165
Other metal cutting machines	18	-	1	1	7	3	3	1	1	1	231
Riveting and welding machines	11	1	1	-	3	3	-	1	1	1	291
Finishing, polishing, and sanding machines	11	-	1	1	3	1	4	1	-	-	300
Forming and casting machines and equipment	13	-	1	1	3	3	3	1	1	-	257
Mechanical material handling and moving equipment:	35	1	2	4	3	10	9	4	1	1	408
Conveyors	20	1	1	1	3	4	5	4	-	1	483
Fork lift trucks, palletizing and other equipment	15	-	1	3	-	6	4	-	1	-	400
Packaging and related equipment	20	1	2	2	4	9	2	-	-	-	229
Assembly and related equipment	20	-	-	1	7	5	4	2	1	-	285
Other equipment	47	2	3	3	8	14	10	5	1	1	250

Table II-1. NUMBER OF WORKERS DISPLACED, BY TYPE OF DISPLACEMENT AND TYPE OF NEW EQUIPMENT

Type of new equipment	Number of cases	Number of workers, by type of displacement				
		Total displaced	Reassigned to new equipment	Transferred elsewhere in plant	Reassigned: elsewhere in plant	Separated
All types and total	259	4,542	1,983	332	1,123	1,104
Replacement cases	210	4,074	1,656	259	1,078	1,081
Replacement and supplementation cases	12	271	135	71	45	20
Supplementation cases	37	197	192	2	-	3
Automatic production lines	12	457	196	8	130	123
Process production	5	326	143	1	65	117
Replacement cases	4	325	143	-	65	117
Supplementation cases	1	1	-	1	-	-
Automatic transfer lines and machines	7	131	53	7	65	6
Replacement cases	7	131	53	7	65	6
Instrumentation additions	36	793	329	18	133	313
Feedback control	9	236	109	-	11	116
Replacement cases	6	228	101	-	11	116
Supplementation cases	3	8	8	-	-	-
Other	27	557	220	18	122	197
Replacement cases	26	549	216	18	122	193
Replacement and supplementation cases	1	8	4	-	-	4
Metalworking machinery and related equipment	95	1,056	598	155	247	56
Numerically controlled machine tools	40	449	302	83	59	5
Replacement cases	8	76	46	11	18	1
Replacement and supplementation cases	9	227	111	71	41	4
Supplementation cases	23	146	145	1	-	-
Electric discharge machines	6	12	12	-	-	-
Replacement cases	2	6	6	-	-	-
Supplementation cases	4	6	6	-	-	-

Continued

Table II-1 - continued

Type of new equipment	Number of cases	Number of workers, by type of displacement				
		Total dis-placed	Reassigned to new equipment	Transferred elsewhere in plant	Reassigned: elsewhere in plant	Separated
Other metal cutting machines	17	124	50	6	61	7
Replacement cases	15	116	45	6	61	4
Replacement and supplementation cases	1	4	4	-	-	-
Supplementation cases	1	4	1	-	-	3
Riveting and welding machines	10	188	94	27	53	14
Replacement cases	7	164	70	27	53	14
Supplementation cases	3	24	24	-	-	-
Finishing, polishing, and sanding machines	11	109	41	-	64	4
Replacement cases	11	109	41	-	64	4
Forming and casting machines and equipment	11	174	99	39	10	26
Replacement cases	11	174	99	39	10	26
Mechanical material handling and moving equipment	33	763	241	71	203	248
Conveyors	18	256	102	19	96	39
Replacement cases	18	256	102	19	96	39
Fork lift trucks, palletizing and other equipment	15	507	139	52	107	209
Replacement cases	15	507	139	52	107	209
Packaging and related equipment	20	326	125	11	103	87
Replacement cases	19	319	118	11	103	87
Supplementation cases	1	7	7	-	-	-
Assembly and related equipment	20	407	145	23	92	147
Replacement cases	19	406	144	23	92	147
Supplementation cases	1	1	1	-	-	-
Other equipment	43	740	349	46	215	130
Replacement cases	42	708	333	46	211	118
Replacement and supplementation cases	1	32	16	-	4	12

Table II-2. SEPARATIONS AS A PERCENT OF DISPLACEMENTS, BY SIZE OF ESTABLISHMENT AND TYPE OF NEW EQUIPMENT

Type of new equipment	All sizes	Size of establishment (number of workers)								
		4 to 19	20 to 49	50 to 99	100 to 199	200 to 499	500 to 999	1,000 to 1,999	2,000 to 4,999	5,000 or more
All types	24.3	69.2	54.5	43.7	34.4	21.3	30.8	24.3	2.0	0.0
Automatic production lines	26.9	-	-	-	71.8	0.0	0.0	10.3	0.0	0.0
Process production	35.9	-	-	-	72.7	0.0	0.0	-	0.0	-
Automatic transfer lines and machines	4.6	-	-	-	0.0	0.0	0.0	10.3	0.0	0.0
Instrumentation additions	39.5	88.9	90.9	52.9	6.7	56.4	77.0	39.6	11.3	0.0
Feedback control	49.2	-	90.9	52.9	0.0	33.3	71.7	24.5	-	-
Other	35.4	88.9	-	-	7.1	57.7	86.8	51.2	11.3	0.0
Metalworking machinery and related equipment	5.3	28.6	6.3	57.7	8.2	3.4	6.8	5.8	0.0	0.0
Numerically controlled machine tools	1.1	0.0	12.5	0.0	0.0	0.0	0.0	7.1	0.0	0.0
Electric discharge machines	0.0	-	0.0	-	0.0	0.0	-	-	-	-
Other metal cutting machines	5.6	-	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0
Riveting and welding machines	7.4	50.0	0.0	-	35.3	0.0	-	-	0.0	0.0
Finishing, polishing, and sanding machines	3.7	-	0.0	0.0	0.0	0.0	5.5	0.0	-	-
Forming and casting machines and equipment	14.9	-	-	100.0	25.0	9.2	0.0	0.0	-	-
Mechanical material handling and moving equipment	32.5	-	72.5	28.6	42.3	31.9	35.3	27.4	0.0	0.0
Conveyors	15.2	-	0.0	0.0	42.3	3.7	0.0	27.4	-	0.0
Fork lift trucks, palletizing and other equipment	41.2	-	78.4	30.0	-	39.4	45.0	-	0.0	-
Packaging and related equipment	26.7	60.0	62.5	75.0	65.9	26.5	0.0	-	-	-
Assembly and related equipment	36.1	-	-	0.0	8.1	26.8	59.6	0.0	0.0	-
Other equipment	17.6	77.8	0.0	28.6	44.3	4.1	23.8	0.0	0.0	0.0

Table III-1. WORKERS ON NEW EQUIPMENT, BY SOURCE AND OCCUPATION

Occupation	All sources	Transferred			Reassigned			Hired
		Total	From old equipment	From elsewhere in plant	Total	From old equipment	From elsewhere in plant	
All occupations	4,115	970	953	17	2,646	1,983	663	499
Assembler	146	44	44	-	96	96	-	6
Craftsman	331	51	51	-	240	219	21	40
Welder	43	2	2	-	19	4	15	22
Toolmaker	62	15	15	-	47	45	2	-
Baker	42	-	-	-	40	36	4	2
Printing craftsman	112	9	9	-	99	99	-	4
Other craftsmen	72	25	25	-	35	35	-	12
Clerical occupations	286	42	42	-	233	11	222	11
Inspectors and testers	35	2	2	-	31	31	-	2
Machine and equipment attendants	875	86	76	10	693	595	98	96
N/C machine tool attendant	256	-	-	-	227	149	78	29
N/C drill press attendant	132	-	-	-	127	75	52	5
N/C milling machine attendant	81	-	-	-	57	47	10	24
Other N/C attendants	43	-	-	-	43	27	16	-
Conveyor attendant	104	31	31	-	51	51	-	22
Packaging machine attendant	116	21	21	-	80	80	-	15
Palletizer attendant	60	-	-	-	60	60	-	-
Other attendants	339	34	24	10	275	255	20	30
Machine and equipment monitors	97	3	3	-	78	61	17	16
Remote control monitor	88	3	3	-	69	52	17	16
Other monitors	9	-	-	-	9	9	-	-
Machine operator	623	155	155	-	429	347	82	39
Metalworking machine operator	195	1	1	-	178	155	23	16
Finishing, polishing and sanding machines	39	-	-	-	37	34	3	2
Extrusion, molding and casting machines	69	-	-	-	65	62	3	4
Other metalworking machine operators	87	1	1	-	76	59	17	10
Other machine operators	428	154	154	-	251	192	59	23
Vehicle operator	129	31	31	-	64	55	9	34
Maintenance man	526	209	206	3	211	192	19	106
Electrical-electronic	68	25	25	-	35	28	7	8
Electro-mechanical	34	4	4	-	29	26	3	1
Mechanical	216	132	132	-	23	15	8	61
Other maintenance men	208	48	45	3	124	123	1	36
Technical occupations	397	29	29	-	330	153	177	38
N/C programmer	74	-	-	-	56	49	7	18
Trouble shooting technician	139	-	-	-	136	26	110	3
Other technical occupations	184	29	29	-	138	78	60	17
Material handler	576	294	290	4	187	170	17	95
General laborer	55	21	17	4	22	22	-	12
Hand packer	117	71	71	-	42	37	5	4
Feeder-offbearer	56	33	33	-	16	16	-	7
Other material handlers	348	169	169	-	107	95	12	72
Other occupations	94	24	24	-	54	53	1	16

Table III-2. NUMBER OF WORKERS REASSIGNED TO NEW EQUIPMENT, BY PREVIOUS AND PRESENT OCCUPATION GROUP

Occupation on new equipment	Previous occupation							
	All previous occupations	Machine and equipment attendant	Machine operator			Technical occupations	Craftsman	Clerical occupations
			All machine operators	Metal-working machines	Other machines			
All occupations	2,646	140	580	343	237	318	293	246
Machine and equipment attendants	693	116	239	203	36	-	32	-
N/C machine tool attendant	227	-	187	187	-	-	30	-
Other attendants	466	116	52	16	36	-	2	-
Machine operator	429	-	238	135	103	4	42	-
Metalworking machines	178	-	138	135	3	-	32	-
Other machines	251	-	100	-	100	4	10	-
Technical occupations	330	-	-	-	-	313	1	-
Craftsman	240	1	4	4	-	-	216	15
Clerical occupations	233	-	-	-	-	-	-	231
Maintenance man	211	2	56	-	56	-	-	-
Material handler	187	-	6	-	6	-	2	-
Assembler	96	-	-	-	-	-	-	-
Machine and equipment monitors	78	21	36	-	36	1	-	-
Vehicle operator	64	-	-	-	-	-	-	-
Inspectors and testers	31	-	-	-	-	-	-	-
Other occupations, n.e.c.	54	-	1	1	-	-	-	-

Continued

Table III-2 - continued

Occupation on new equipment	Previous occupation							
	Maintenance man	Material handler	Assembler	Machine and equipment monitors	Vehicle operator	Inspectors and testers	Other occupations n.e.c.	Occupation not reported
All occupations	175	487	183	11	19	10	87	97
Machine and equipment attendants	12	221	34	-	2	-	8	29
N/C machine tool attendant	-	-	-	-	-	-	-	10
Other attendants	12	221	34	-	2	-	8	19
Machine operator	1	32	44	-	7	-	17	44
Metalworking machines	-	4	-	-	-	-	-	4
Other machines	1	28	44	-	7	-	17	40
Technical occupations	13	-	-	-	-	-	3	-
Craftsman	-	-	-	-	-	-	-	4
Clerical occupations	-	-	-	-	-	-	-	2
Maintenance man	140	9	2	-	-	-	-	2
Material handler	-	159	6	-	-	-	6	8
Assembler	-	-	96	-	-	-	-	-
Machine and equipment monitors	9	-	-	11	-	-	-	-
Vehicle operator	-	46	-	-	10	-	-	8
Inspectors and testers	-	20	-	-	-	10	1	-
Other occupations, n.e.c.	-	-	1	-	-	-	52	-

Table III-3. NUMBER OF NEW AND REASSIGNED WORKERS ON NEW EQUIPMENT WHO WERE TRAINED, BY TRAINING AGENCY AND OCCUPATION

Occupation	Training agency						
	All training agencies	Company only	Equipment manufacturer only			Both company and manufacturer	Not reported
			At company plant	At manufacturers plant or school	At both		
All occupations	2,135	1,540	340	153	12	78	12
Assembler	42	40	2	-	-	-	-
Craftsman	237	173	58	4	-	2	-
All-round machinist	5	5	-	-	-	-	-
Welder	22	21	-	-	-	1	-
Toolmaker	46	8	36	2	-	-	-
Baker	42	30	12	-	-	-	-
Printing craftsman	103	103	-	-	-	-	-
Machine set-up man	19	6	10	2	-	1	-
Clerical occupations	231	228	1	1	-	-	1
Inspectors and testers	10	10	-	-	-	-	-
Machine and equipment attendants	530	367	92	52	-	15	4
N/C machine tool attendant	139	71	55	2	-	7	4
N/C drill press attendant	92	53	30	-	-	5	4
N/C milling machine attendant	21	2	17	-	-	2	-
Other N/C machine tool attendants	26	16	8	2	-	-	-
Conveyor attendant	47	47	-	-	-	-	-
Packaging machine attendant	62	46	16	-	-	-	-
Palletizer attendant	38	38	-	-	-	-	-
Other attendants	244	165	21	50	-	8	-
Machine and equipment monitors	74	22	17	17	-	18	-
Remote control monitor	65	13	17	17	-	18	-
Other monitors	9	9	-	-	-	-	-
Machine operator	300	215	54	20	-	11	-
Metalworking machine operator	130	94	24	2	-	10	-
Finishing, polishing, and sanding machines	35	19	16	-	-	-	-
Extrusion, molding, and casting machines	37	35	2	-	-	-	-
Other metalworking machine operators	58	40	6	2	-	10	-
Other machine operator	170	121	30	18	-	1	-
Vehicle operator	56	56	-	-	-	-	-
Maintenance man	194	55	83	20	11	21	4
Electrical-electronic	30	1	12	11	2	4	-
Electro-mechanical	28	20	3	4	1	-	-
Mechanical	43	3	36	4	-	-	-
Other maintenance men	93	31	32	1	8	17	4
Technical occupations	311	239	32	27	1	9	3
N/C programmer	53	3	25	21	1	-	3
Troubleshooting technician	139	126	1	3	-	9	-
Other technical occupations	119	110	6	3	-	-	-
Semi-skilled operative, n.e.c.	6	6	-	-	-	-	-
Material handler	115	114	-	-	-	1	-
Other occupations	29	15	1	12	-	1	-

Table III-4. NUMBER OF NEW AND REASSIGNED WORKERS ON NEW EQUIPMENT WHO WERE TRAINED, BY PURPOSE OF TRAINING AND OCCUPATION

Occupation	Purpose of training				
	All purposes	Beginning workers	Retrain for new skills	Supplement skills	Not reported
All occupations	2,135	27	300	1,610	198
Assembler	42	-	-	42	-
Craftsman	237	-	15	222	-
All-round machinist	5	-	-	5	-
Welder	22	-	-	22	-
Toolmaker	46	-	-	46	-
Baker	42	-	-	42	-
Printing craftsman	103	-	15	88	-
Machine set-up man	19	-	-	19	-
Clerical occupations	231	-	-	224	7
Inspectors and testers	10	2	-	8	-
Machine and equipment attendants	530	2	139	336	53
N/C machine tool attendant	139	-	-	137	2
N/C drill press attendant	92	-	-	90	2
N/C milling machine attendant	21	-	-	21	-
Other N/C attendants	26	-	-	26	-
Conveyor attendant	47	-	23	4	20
Packaging machine attendant	62	2	20	39	1
Palletizer attendant	38	-	38	-	-
Other attendants	244	-	58	156	30
Machine and equipment monitors	74	-	14	44	16
Remote control monitor	65	-	14	35	16
Other monitors	9	-	-	9	-
Machine operator	300	16	21	223	40
Metalworking machine operator	130	2	8	117	3
Finishing, polishing, and sanding machines	35	-	4	31	-
Extrusion, molding, and casting machines	37	2	-	35	-
Other metalworking machine operators	58	-	4	51	3
Other machine operators	170	14	13	106	37
Vehicle operator	56	-	40	8	8
Maintenance man	194	1	11	172	10
Electrical-electronic	30	-	-	30	-
Electro-mechanical	28	1	-	27	-
Mechanical	43	-	-	43	-
Other maintenance men	93	-	11	72	10
Technical occupations	311	-	37	272	2
N/C programmer	53	-	-	51	2
Troubleshooting technician	139	-	-	139	-
Other technical occupations	119	-	37	82	-
Semiskilled operatives, n.e.c.	6	-	-	6	-
Material handler	115	6	21	26	62
Other occupations (incl. service workers)	29	-	2	27	-

Table IV-1. CHANGE IN SKILL LEVEL OF WORKERS REASSIGNED AND TRANSFERRED FROM OLD TO NEW EQUIPMENT, BY SELECTED OCCUPATION DETAIL

Previous occupation	Present occupation	Percent distribution of workers according to change in skill level					
		Total	To job with lower skill	To job with higher skill	No change in skill level		
					Total	Re-assigned	Trans-ferred
All occupations	All occupations	100.0	10.9	20.8	68.3	35.8	32.5
Assembler		100.0	20.4	21.2	58.4	38.9	19.5
	Assembler	100.0	-	29.3	70.7	39.3	31.4
	Machine and equipment attendant, n.e.c.	100.0	55.9	2.9	41.2	41.2	-
	Machine operator, n.e.c.	100.0	62.8	11.6	25.6	25.6	-
	Maintenance man, n.e.c.	100.0	-	-	100.0	100.0	-
	Material handler	100.0	-	-	100.0	100.0	-
	Semi-skilled, operator, n.e.c.	100.0	-	100.0	-	-	-
Craftsman		100.0	14.8	15.7	69.5	53.8	15.7
Welder	Welder	100.0	33.3	16.7	50.0	16.7	33.3
Molder and caster		100.0	100.0	-	-	-	-
	Metal extrusion, etc.	100.0	100.0	-	-	-	-
	Machine operator, n.e.c.	100.0	100.0	-	-	-	-
	Material handler	100.0	100.0	-	-	-	-
Toolmaker		100.0	3.3	4.9	91.8	67.2	24.6
	Toolmaker	100.0	1.7	5.0	93.3	68.3	25.0
	Metalworking machine operator, n.e.c.	100.0	100.0	-	-	-	-
Baker	Baker	100.0	-	100.0	-	-	-
Printing craftsman		100.0	2.1	-	97.9	88.4	9.5
	Printing craftsman	100.0	-	-	100.0	90.3	9.7
	Machine and equipment attendant, n.e.c.	100.0	100.0	-	-	-	-
Machine set-up man		100.0	3.2	35.5	61.3	45.2	16.1
	Machine set-up man	100.0	-	43.5	56.5	34.8	21.7
	N/C drill press attendant	100.0	50.0	50.0	-	-	-
	Metalworking machine operator, n.e.c.	100.0	-	-	100.0	100.0	-

Continued

Table IV-1- continued

Previous occupation	Present occupation	Percent distribution of workers according to change in skill level					
		Total	To job with lower skill	To job with higher skill	No change in skill level		
					Total	Re-assigned	Trans-ferred
	Machine operator, n.e.c.	100.0	-	-	100.0	100.0	-
	N/C programmer	100.0	-	-	100.0	100.0	-
Other craftsmen, n.e.c.		100.0	8.3	-	91.7	58.4	33.3
	Other craftsmen, n.e.c.	100.0	12.5	-	87.5	25.0	62.5
	N/C milling machine operator	100.0	-	-	100.0	100.0	-
	Machine operator, n.e.c.	100.0	50.0	-	50.0	50.0	-
Clerical occupations		100.0	-	22.1	77.9	16.2	61.7
	Welder	100.0	-	100.0	-	-	-
	Printing craftsman	100.0	-	100.0	-	-	-
	Clerical occupations	100.0	-	-	100.0	20.8	79.2
Inspectors and testers	Inspectors and testers	100.0	66.6	-	33.4	16.7	16.7
Machine and equipment attendant		100.0	2.4	37.0	60.6	22.6	38.0
Packaging machine attendant		100.0	-	6.5	93.5	47.8	45.7
	Machine set-up man	100.0	-	100.0	-	-	-
	Packaging machine attendant	100.0	-	-	100.0	51.2	48.8
	Maintenance man, n.e.c.	100.0	-	100.0	-	-	-
Other attendants		100.0	3.1	45.7	51.2	15.4	35.8
	Conveyor attendant	100.0	3.1	-	96.9	-	96.9
	Machine and equipment attendant, n.e.c.	100.0	3.5	53.9	42.6	21.7	20.9
	Remote control monitor	100.0	-	80.0	20.0	-	20.0
Machine and equipment monitor		100.0	-	100.0	-	-	-
Remote control monitor	Remote control monitor	100.0	-	100.0	-	-	-
Other monitors	Remote control monitor	100.0	-	100.0	-	-	-
Machine operator		100.0	26.8	22.9	50.3	25.6	24.7
Metalworking machine operator		100.0	47.0	10.4	42.6	42.2	0.4
Drill press operator		100.0	47.9	9.6	42.5	42.5	-

Continued

Table IV-1 - continued

Previous occupation	Present occupation	Percent distribution of workers according to change in skill level: Total	To job with lower skill	To job with higher skill	No change in skill level: Total	No change in skill level: Re-assigned	No change in skill level: Trans-ferred
	Machine and equipment attendant, n.e.c.	100.0	-	-	100.0	100.0	-
	N/C drill press attendant	100.0	47.7	7.5	44.8	44.8	-
	Drill press operator	100.0	75.0	25.0	-	-	-
	Other occupations	100.0	-	100.0	-	-	-
Lathe operator		100.0	39.1	34.8	26.1	26.1	-
	Machine set-up man	100.0	-	-	100.0	100.0	-
	Lathe operator	100.0	27.2	36.4	36.4	36.4	-
	N/C lathe attendant	100.0	60.0	40.0	-	-	-
Milling machine operator		100.0	52.0	16.7	31.3	31.3	-
	N/C drill press attendant	100.0	100.0	-	-	-	-
	N/C milling machine attendant	100.0	73.4	13.3	13.3	13.3	-
	N/C machining center attendant	100.0	80.0	20.0	-	-	-
	Milling machine operator	100.0	-	23.5	76.5	76.5	-
Metal finishing, etc.		100.0	54.1	2.7	43.2	43.2	-
	Machine and equipment attendant, n.e.c.	100.0	100.0	-	-	-	-
	N/C drill press attendant	100.0	-	-	100.0	100.0	-
	Metal finishing, etc.	100.0	53.1	3.1	43.8	43.8	-
Metal extrusion,etc.		100.0	54.4	4.3	41.3	41.3	-
	Machine and equipment attendant, n.e.c.	100.0	92.6	7.4	-	-	-
	Metal extrusion, etc.	100.0	-	-	100.0	100.0	-
Other metalworking machine operator		100.0	29.3	4.9	65.8	63.4	2.4
	Machine set-up man	100.0	-	-	100.0	100.0	-
	Machine and equipment attendant, n.e.c.	100.0	42.9	-	57.1	57.1	-
	N/C milling machine attendant	100.0	75.0	-	25.0	25.0	-

Continued

Table IV-1 - continued

Previous occupation	Present occupation	Percent distribution of workers according to change in skill level					
		Total	To job with lower skill	To job with higher skill	No change in skill level		
					Total	Re-assigned	Trans-ferred
	N/C machining center attendant	100.0	-	-	100.0	100.0	-
	N/C attendants, n.e.c.	100.0	33.3	-	66.7	66.7	-
	Metalworking machine operator, n.e.c.	100.0	19.0	9.5	71.5	66.7	4.8
Other machine operators		100.0	11.7	32.2	56.1	13.3	42.8
	Packaging machine attendant	100.0	-	-	100.0	100.0	-
	Machine and equipment attendant, n.e.c.	100.0	76.0	8.0	16.0	16.0	-
	Remote control monitor	100.0	-	100.0	-	-	-
	Other monitors, n.e.c.	100.0	-	100.0	-	-	-
	Machine operators, n.e.c.	100.0	5.7	29.1	65.2	13.2	52.0
	Material handler, n.e.c.	100.0	100.0	-	-	-	-
Vehicle operator		100.0	4.1	8.2	87.7	24.5	63.2
	Conveyor attendant	100.0	100.0	-	-	-	-
	Machine operator, n.e.c.	100.0	-	57.1	42.9	42.9	-
	Vehicle operator	100.0	-	-	100.0	22.5	77.5
Maintenance man		100.0	0.3	21.3	78.4	21.3	57.1
Electrical-electronic		100.0	-	18.3	81.7	33.3	48.4
	Remote control monitor	100.0	-	100.0	-	-	-
	Electrical-electronic	100.0	-	2.0	98.0	40.0	58.0
	Maintenance man, n.e.c.	100.0	-	100.0	-	-	-
	Troubleshooting technician	100.0	-	100.0	-	-	-
Electro-mechanical	Electro-mechanical	100.0	-	30.0	70.0	30.0	40.0
Mechanical		100.0	-	16.8	83.2	6.9	76.3
	Remote control monitor	100.0	-	100.0	-	-	-
	Machine operator, n.e.c.	100.0	-	-	100.0	100.0	-
	Electro-mechanical	100.0	-	100.0	-	-	-
	Mechanical	100.0	-	5.4	94.6	4.8	89.8
	Maintenance man, n.e.c.	100.0	-	-	100.0	100.0	-
Other maintenance man		100.0	0.8	28.8	70.4	35.7	34.7

Continued

Table IV-1 - continued

Previous occupation	Present occupation	Percent distribution of workers according to change in skill level					
		Total	To job with lower skill	To job with higher skill	No change in skill level		
					Total	Re-assigned	Trans-ferred
	Machine and equipment attendant, n.e.c.	100.0	-	-	100.0	100.0	-
	Remote control monitor	100.0	-	100.0	-	-	-
	Electrical-electronic	100.0	14.3	85.7	-	-	-
	Maintenance man, n.e.c.	100.0	-	21.1	78.9	33.3	45.6
	Troubleshooting technician	100.0	-	100.0	-	-	-
Technical occupations		100.0	1.2	19.9	78.9	61.9	17.0
Methods man		100.0	-	3.4	96.6	82.8	13.8
	N/C programmer	100.0	-	6.5	93.5	93.5	-
	Methods man	100.0	-	-	100.0	70.4	29.6
Troubleshooting technician	Troubleshooting technician	100.0	-	81.2	18.8	18.8	-
Other technical occupations		100.0	2.1	19.6	78.3	56.7	21.6
	Remote control monitor	100.0	-	100.0	-	-	-
	N/C programmer	100.0	-	72.7	27.3	27.3	-
	Technical occupation, n.e.c.	100.0	2.4	11.8	85.8	61.1	24.7
Semi-skilled operatives, n.e.c.		100.0	41.4	-	58.6	36.2	22.4
	Inspectors and testers	100.0	-	-	100.0	100.0	-
	Machine and equipment attendant, n.e.c.	100.0	37.5	-	62.5	62.5	-
	Machine operator, n.e.c.	100.0	70.6	-	29.4	29.4	-
	Feeder-offbearer	100.0	100.0	-	-	-	-
	Semi-skilled operatives, n.e.c.	100.0	11.5	-	88.5	38.5	50.0
Material handler		100.0	1.8	16.4	81.8	43.8	38.0
General laborer		100.0	4.0	26.3	69.7	52.5	17.2
	Conveyor attendant	100.0	-	-	100.0	100.0	-
	Palletizer attendant	100.0	-	-	100.0	100.0	-
	Packaging machine attendant	100.0	-	-	100.0	100.0	-
	Machine and equipment attendant, n.e.c.	100.0	23.1	69.2	7.7	7.7	-

Continued

Table IV-1 - continued

Previous occupation	Present occupation	Percent distribution of workers according to change in skill level					
		Total	To job with lower skill	To job with higher skill	No change in skill level		
					Total	Re-assigned	Trans-ferred
	Machine operator, n.e.c.	100.0	100.0	-	-	-	-
	Vehicle operator	100.0	-	100.0	-	-	-
	Maintenance man, n.e.c.	100.0	-	100.0	-	-	-
	General laborer	100.0	-	3.6	96.4	35.7	60.7
	Material handler, n.e.c.	100.0	-	-	100.0	100.0	-
Hand packer		100.0	1.1	20.6	78.3	37.7	40.6
	Inspectors and testers	100.0	-	-	100.0	100.0	-
	Packaging machine attendant	100.0	-	82.4	17.6	17.6	-
	Machine operator, n.e.c.	100.0	-	-	100.0	100.0	-
	Maintenance man, n.e.c.	100.0	-	100.0	-	-	-
	General laborer	100.0	100.0	-	-	-	-
	Hand packer	100.0	-	2.0	98.0	25.5	72.5
Feeder-offbearer		100.0	0.6	11.0	88.4	67.1	21.3
	Conveyor attendant	100.0	-	-	100.0	100.0	-
	Palletizer attendant	100.0	-	-	100.0	100.0	-
	Packaging machine attendant	100.0	-	37.5	62.5	62.5	-
	Machine and equipment attendant, n.e.c.	100.0	-	-	100.0	100.0	-
	Machine operator, n.e.c.	100.0	-	100.0	-	-	-
	Vehicle operator	100.0	-	100.0	-	-	-
	General laborer	100.0	100.0	-	-	-	-
	Hand packer	100.0	-	100.0	-	-	-
	Feeder-offbearer	100.0	-	-	100.0	21.4	78.6
Other material handler		100.0	2.1	13.8	84.1	33.5	50.6
	Conveyor attendant	100.0	-	21.1	78.9	78.9	-
	Packaging machine attendant	100.0	-	100.0	-	-	-
	Machine and equipment attendant, n.e.c.	100.0	57.1	14.3	28.6	28.6	-
	Machine operator, n.e.c.	100.0	-	-	100.0	100.0	-
	Vehicle operator	100.0	-	86.2	13.8	13.8	-

Continued

Table IV-1 - continued

Previous occupation	Present occupation	Percent distribution of workers according to change in skill level					
		Total	To job with lower skill	To job with higher skill	No change in skill level		
					Total	Re-assigned	Trans-ferred
	General laborer	100.0	-	-	100.0	100.0	-
	Hand packer	100.0	-	-	100.0	100.0	-
	Feeder-offbearer	100.0	-	100.0	-	-	-
	Material handler, n.e.c.	100.0	1.2	5.4	93.4	27.9	65.5
Other occupations, n.e.c.		100.0	-	49.0	51.0	28.6	22.4
	N/C programmer	100.0	-	-	100.0	100.0	-
	Other occupations, n.e.c.	100.0	-	52.2	47.8	23.9	23.9

Table IV-2. SKILL LEVEL CHANGE, BY FUNCTION ON NEW EQUIPMENT AND OCCUPATION GROUP

Occupation group and function	Distribution of worker-functions by skill-level change				Average rating of function
	Total	Lower	Same	Higher	
All occupations	2,300	429	1,567	304	1.95
Tending	566	230	296	40	1.66
Material handling	544	33	491	20	1.98
Machine operation	378	109	229	40	1.82
Set-up	225	50	130	45	1.98
Troubleshooting and maintenance	203	2	147	54	2.26
Assembly	130	-	89	41	2.32
Data functions	98	-	92	6	2.06
Motor vehicle operation	91	-	36	55	2.60
Inspecting and testing	65	5	57	3	1.97
Assembler	113	-	71	42	2.37
Assembly	110	-	69	41	2.37
Machine operation	2	-	2	-	2.00
Inspecting and testing	1	-	-	1	3.00
Material handler	318	1	297	20	2.06
Material handling	302	1	282	19	2.06
Machine operation	7	-	6	1	2.14
Assembly	6	-	6	-	2.00
Tending	3	-	3	-	2.00
Machine and equipment attendants	645	184	438	23	1.75
Tending	390	125	257	8	1.70
Material handling	117	18	99	-	1.85
Set-up	60	37	11	12	1.58
Inspecting and testing	27	4	23	-	1.85
Machine operation	19	-	19	-	2.00
Troubleshooting and maintenance	14	-	12	2	2.14
Assembly	11	-	11	-	2.00
Motor vehicle operation	4	-	4	-	2.00
Data functions	3	-	2	1	2.33
Machine and equipment monitors	65	2	53	10	2.12
Tending	42	2	34	6	2.10
Troubleshooting and maintenance	8	-	8	-	2.00
Material handling	7	-	7	-	2.00
Machine operation	4	-	-	4	3.00
Inspecting and testing	4	-	4	-	2.00
Machine operator	355	129	195	31	1.72
Machine operation	174	42	104	28	1.92
Tending	82	82	-	-	1.00
Material handling	61	-	61	-	2.00
Set-up	29	4	22	3	1.97
Motor vehicle operation	6	-	6	-	2.00
Inspecting and testing	3	1	2	-	1.67

Continued

Table IV-2 - continued

Occupation group and function	Distribution of worker-functions by skill-level change: Total	Lower	Same	Higher	Average rating of function
Vehicle operator	83	4	24	55	2.61
Motor vehicle operation	79	-	24	55	2.70
Material handling	4	4	-	-	1.00
Inspectors and testers	18	8	10	-	1.56
Inspecting and testing	10	-	10	-	2.00
Machine operation	8	8	-	-	1.00
Other semi-skilled operators, n.e.c.	44	3	32	9	2.14
Material handling	19	-	18	1	2.05
Tending	8	-	1	7	2.88
Inspecting and testing	6	-	6	-	2.00
Troubleshooting and maintenance	4	-	4	-	2.00
Machine operation	3	3	-	-	1.00
Assembly	3	-	3	-	2.00
Data functions	1	-	-	1	3.00
Clerical occupations	53	4	48	1	1.94
Machine operation	47	4	42	1	1.94
Motor vehicle operation	2	-	2	-	2.00
Material handling	2	-	2	-	2.00
Data functions	2	-	2	-	2.00
Craftsman	325	91	192	42	1.85
Set-up	131	9	92	30	2.16
Machine operation	110	51	53	6	1.59
Material handling	30	10	20	-	1.67
Tending	26	21	1	4	1.35
Data functions	14	-	14	-	2.00
Troubleshooting and maintenance	7	-	5	2	2.29
Inspecting and testing	7	-	7	-	2.00
Maintenance man	164	2	116	46	2.27
Troubleshooting and maintenance	155	2	109	44	2.27
Machine operation	3	-	3	-	2.00
Set-up	2	-	2	-	2.00
Inspecting and testing	2	-	-	2	3.00
Material handling	2	-	2	-	2.00
Technical occupations	83	1	73	9	2.11
Data functions	67	-	63	4	2.06
Troubleshooting and maintenance	9	-	4	5	2.67
Inspecting and testing	5	-	5	-	2.00
Set-up	1	-	1	-	2.00
Machine operation	1	1	-	-	1.00
Other occupations, n.e.c.	34	-	18	16	2.47
Tending	15	-	-	15	3.00
Data functions	11	-	11	-	2.00
Troubleshooting and maintenance	6	-	5	1	2.17
Set-up	2	-	2	-	2.00